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THOS. P. HINMAN, D. D. S., ATLANTA, GEORGIA.

President National Dental Association.

Professor of Operative Dentistry and Oral Surgery,
Atlanta Dental College.

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ORIGINAL COMMUNICATIONS.

EVOLUTION OF BODILY MOVEMENT OF TEETH.

By Carl B. Case, D. D. S., Milwaukee, Wis.

(Read before the National Dental Association.)

WHILE the term "Bodily Movement" is not particularly euphonious, it never-the-less expresses more definitely than any other term, the movement of a tooth-root in its entirety in a given direction, either forward, backward or laterally. The crown of the tooth usually, tho not necessarily, participates in the movement which should refer more particularly to the tooth root and its surrounding embendment.

This is possibly the reason why some writers have employed the term "root movement." This form of terminology, however, is too ambiguous and elastic to have a definite meaning as any movement of a tooth, whether bodily, inclination, rotary, extruding or intruding, may likewise be classified under the head of "root movement." Therefore, I offer the suggestion that the term "bodily movement" be generally and more appropriately adopted.

It is probably a natural inference, judging from various essays offered to the dental profession during the last three or four years, that the forward or backward bodily movement of anterior teeth is a comparatively new and wonderfully important method of practice in orthodontia.

It is certainly a pleasure to realize that bodily movement of teeth has at last come into its own and that it now occupies a position of importance in the field of orthodontia second to none, tho it was not generally acknowledged or accepted either as a possibility or a necessity until a few years ago; moreover, it was maligned and viewed with skepticism altho such a movement of teeth was scientifically and successfully practiced

in numerous cases as early as 1892, or almost as early as orthodontia came to be regarded as an active science.

Altho the first apparatus devised for the forward bodily movement of the four or six anterior teeth, en phalanx, so to speak, was comparatively crude, the principles involved in general mechanical construction and application of force, have remained unchanged after twenty years of continued practical demonstration,—except, of course, the additions which have been made in the form of auxiliary forces.

The basic principle of the original apparatus (See left of Fig. 1) was the application of force at two points upon the anterior teeth from a stationary anchorage, each force being definitely controlled by the screw nuts at either end of the anchorage tubes.

One force exerts a forward pressure upon the roots of the anterior teeth thru the medium of upright or rootwise bars soldered firmly to the label surfaces of of the bands. These bands with their rootwise bars are so rigidly attached to the teeth that power applied to the uprights is to all intents and purposes the same, and affords the same identical results as applying it directly to the root of the tooth itself at a point in the line of the direction of force, were that possible. The other force or fulcrum bow is intended to offer a resistance to the forward movement of the crowns.

It may be well to call your attention to the fact that each anchorage of this original apparatus which was made in 1892, was provided with a short post and protecting shield for the attachment of the intermaxillary elastics. Its application in this apparatus was the first time in the history of intermaxillary force in which it was applied specifically for the disto-mesial movement of upper and lower dentures, notwithstanding the false claims and ineffectual efforts which were later made to seize the credit and honor under the name "Baker Anchorage."

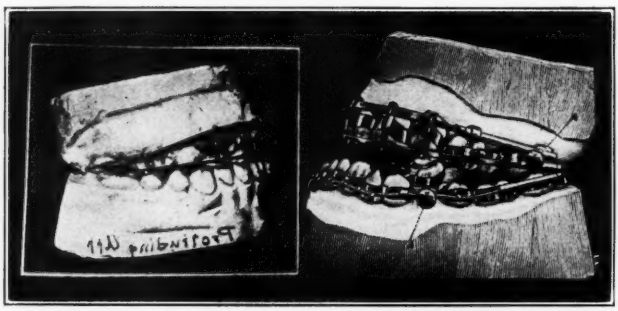

Figure 1.

Altho, in comparison with the more modern contour apparatus on the left this appliance was crude in every particular; in the shape of the rootwise bars, the light weight flattened power bow and the arrangement of the anchorage bands and tubes, it proved conclusively that the application of the power in this manner was not only theoretically correct but indisputably efficient as is so well shown by the plaster casts of one of the three early cases which was corrected in this manner. (See Fig. 2).

I have chosen this particular case, not because it was the most difficult of correction or because it shows the greatest movement of the teeth or of facial de-

velopment, but because it illustrates so perfectly an extensive forward bodily movement of the upper incisors which carried with them the entirely incisive alveolar ridge. (Fig. 3).

cause at the beginning, as can be seen, these teeth were labially inclined, while at the close of the operation they were in a more upright position.

This next cast also (See Fig. 5) fairly

Figure 2.

Please note the position of the incisors and alveolar ridge in relation to the cuspids in the palatal aspect of the upper, and the relations of these teeth to the lower incisors when the jaws were closed. In the upper finished model note how the alveolar arch and incisor teeth were carried forward in relation to the cuspids and lower teeth, and too in Fig. 4 how the apical ends of the roots were moved further than the incisal, because

illustrates what has been accomplished by both orthodontists and general practitioners in the bodily protruding and retruding of the front teeth in hundreds of cases in the past twenty years by the apparatus which the inventor named the Contouring Apparatus, because the need of developing and correcting facial contours was the mother of the conception. Moreover, no movement of the teeth is so perfectly calculated for the correction

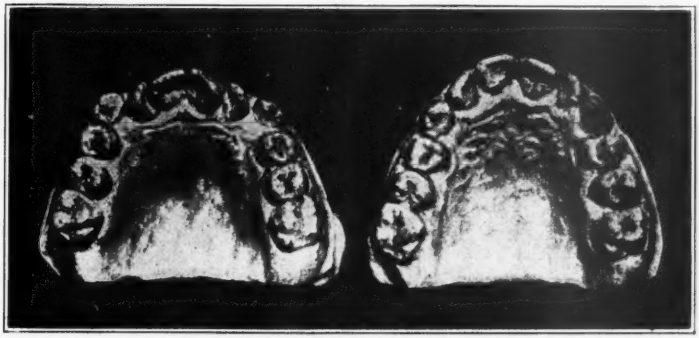

Figure 3.

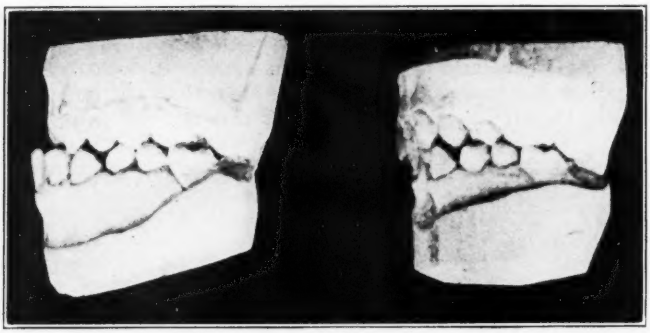

Figure 4.

Figure 5.

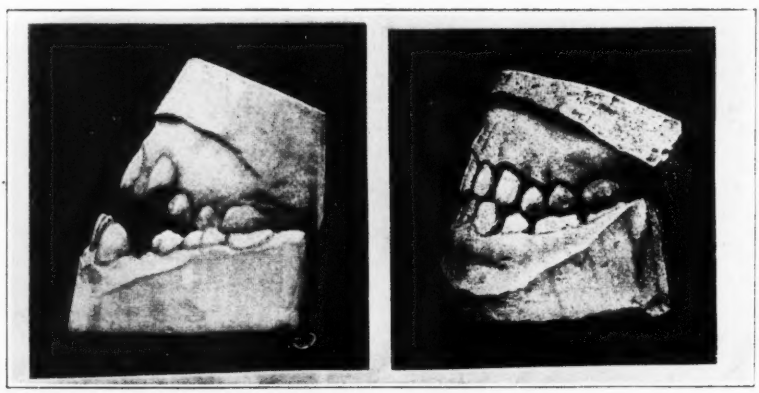

Figure 6.

of facial outlines as a bodily movement, whether it be accomplished with the Case or the Angle apparatus—the principle remains the same.

It was in connection with this particular case (Fig. 6) which was recorded at that time that the first paper ever presented on bodily disto-mesial movement of anterior teeth was read before the Chicago Dental Society, February 2nd, 1893.

At the International Dental Congress in August, 1893, this case with two others, (one of which was shown) which had been completed, was again presented and

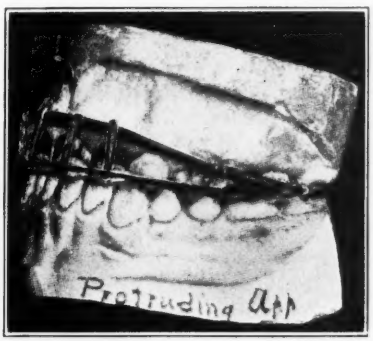

Figure 7.

illustrated with complete dental and facial casts.

The modern contour apparatus (Fig. 7) offers a number of great improvements which increases its efficiency to a remarkable degree.

The anchorage is composed of two bands, or preferably three (See Fig. 8) firmly united with solder and interstitial re-inforcements. The fulcrum tube No. 22 which corresponds to the ordinary arch or alignment-bow tube lies close to the buccal-occlusal margin of the two forward anchorage bands in line with the incisal angles of the incisor teeth.

The power tube No. 13, at its posterior end rests diagonally upon the fulcrum tube so that its direction is as nearly as possible in line with the labio-gingival margin of the cuspid. The results are—more perfect direction of power, less curved power bow, and closer adaptation to the teeth.

The power bow is provided with a series of notches on its anterior surface which correspond to the position of the rootwise bars or uprights on the anterior bands with which it engages, as will be readily seen.

The uprights which equip the anterior

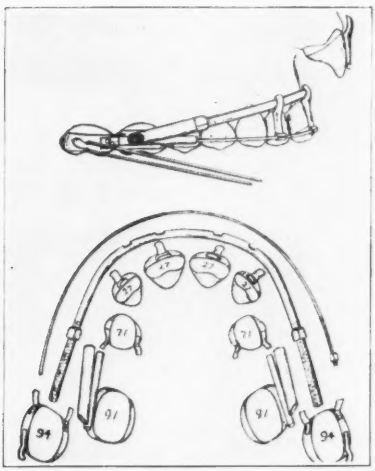

Figure 8.

bands are made from single pieces of metal rolled to the required thickness and stamped, filed or ground into shape so that they are well adapted to the perpendicular labial curve of the band to which they are securely soldered and curve sufficiently outward and up at the gingiva to afford a resting place for the power bow behind them.

This form of upright is a great improvement over the original one as rigidity of upright, band, and tooth as a unit is more pronounced. At the incisal ends, the uprights are each provided with a deep groove, or preferably an open tube, which accommodates the fulcrum wire.

It will very readily be seen how perfect is the control of the anterior tooth movement with such an apparatus which changes from active to passive, permitting the crown of the tooth to move forward.

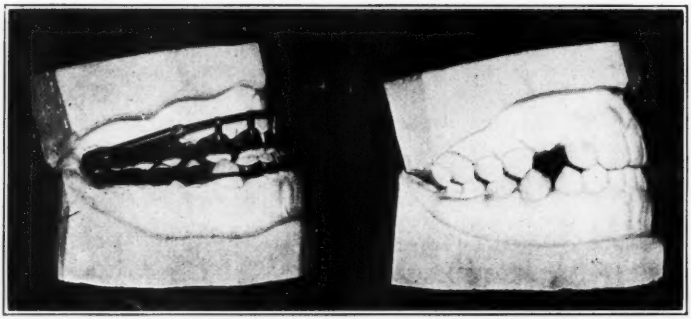

Figure 9.

provides a power that can be regulated to the fraction of a pound by a slight turn of a nut, more or less, and which

This apparatus is also equipped with a hook upon the buccal surface of the posterior band which affords an attachment

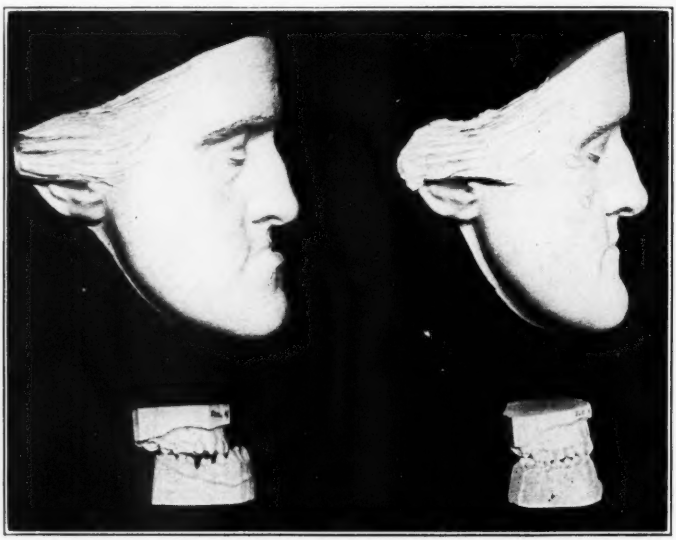

Figure 10.

can instantly be transformed from a power to a fulcrum. It is likewise true that the fulcrum wire may be changed to a tractive power by a slight up-turn of the nut, or by loosening it the fulcrum

for its important auxiliary, the intermaxillary elastic as it has been proved innumerable times, that the great majority of cases requiring forward bodily movement of anterior teeth, also require a disto-

mesial movement of both upper and lower denture.

In reference to the rootwise bars or power arms upon the anterior bands, it is a pleasure to be able to quote such a well known man as Dr. Ottolengui of New York who, at the discussion of a paper upon the subject of "Bodily Movement," presented by Dr. Calvin Case before the First District Dental Society of New York in 1907, said:

"This is an opportunity for which I have been waiting many years. Dr. Case explained this power arm at Old Point Comfort in 1894 and in the discussion I claimed that he gained nothing by extending the arm beyond the neck of the tooth. Tonight that view has again been expressed by Dr. Farrar and by Dr. Jackson. I am very glad of that because it shows that I have not been the only one to take this view; but I have been waiting all this time for an opportunity to tell him that he is absolutely correct and that in my opinion the power arm and the use of the lever in this particular manner, is one of the most valuable additions to orthodontia technic that has been given us by any man."

Fig. 9 is illustrative of a common case which would result in bilateral maleruption of the cuspids with upper incisors occluding lingually. The protruding contour apparatus was employed to carry the incisors bodily forward to their normal occlusion, thus opening space to permit the normal eruption of the cuspids.

As the upper buccal teeth were slightly back of their normal occlusion, the lower apparatus was employed solely as an attachment for the intermaxillary elastics which were looped over the end of the fulcrum tube on the upper anchorage, instead of the usual hooks.

Fig. 10 is the case of a patient 26 years of age. The unusual retruded condition of the upper teeth was due to resorption of the maxilla brought about by carelessness and neglect which resulted in the loss of five anterior and buccal teeth.

Both dentures were provided with a contour apparatus which had for their objects the forward bodily movement of the upper crowns and roots, and the dis-

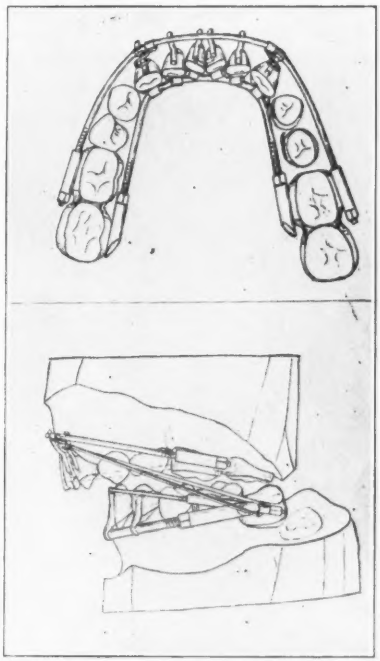

Figure 11.

tal movement of the lower anterior tooth roots.

Fig. 11. The lower apparatus was radically different than that in common use, tho power and resistance were distributed at approximately the same points upon the anterior teeth.

The anchorage bands were each equipped with a single buccal tube which supported the power bow of No. 18 wire threaded at each end.

Retractive power was provided by intermaxillary elastics attached to hooks or spurs on each side of the power bow

which engaged with short open tubes on the cuspid uprights. The nuts at the posterior ends of the bow were to supply a retractive power, or to take up the slack produced by the elastics.

On the lingual aspect at the gingival margin each anchorage was provided with a single tube which received the threaded ends of a fulcrum or resistance bow. This bow rested in open tubes at the linguo-incisal margins of the incisors and cuspid bands, and could be loosened or tightened by a turn of the nuts at the forward ends of the tubes.

The efficiency of both appliances as well as the intermaxillary elastics, is evidenced by the final result.

Fig. 12 illustrates the application of the same principles to the upper denture for the disto-bodily movement of anterior teeth, tho the device is so constructed that absolute control is assured over the inclination or disto-bodily movement.

The anchorage tubes which point in the line of force are well separated and lie more nearly parallel than in the protruding apparatus. The power bow No. 16 is considerably smaller than the one employed in the protruding apparatus because it exerts a tractive or pull force upon the rootwise bars, and does not need to be so large. The fulcrum bow is of approximately the same size as it must offer a sufficient resistance to the distal movement of the crowns.

While it is intended that the traction power upon the rootwise bars shall be the primary medium of movement, it is evident that either bow may be made active as power or fulcrum so that bodily movement may be absolutely and unconditionally controlled.

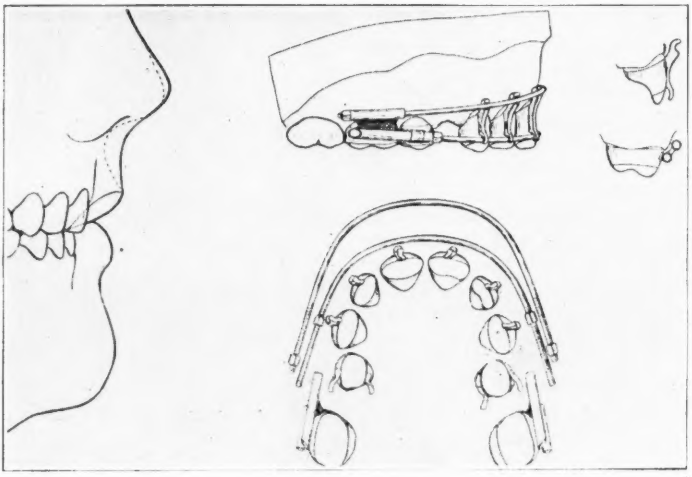

Figure 12.

One of the early cases shown by Fig. 13 which called for correction with this apparatus, was presented before the Odontological Society of New York in 1895. It will be observed that the upper first bicuspids were extracted and the space subsequently closed as much by a forward movement of the molars as by a backward movement of the anterior teeth.

It will also be observed that the cervical portions of the incisors have not

materially changed their relative positions, tho the apices of the roots must have moved distally fully one-quarter of an inch, judging from the final inclination of these teeth, as compared with the first casts. But what seems to be of greater importance is the remarkable improvement in the face. (See Fig. 14.)

After more than 15 years of continued practical application of this principle and its proven benefits, it would be strange,

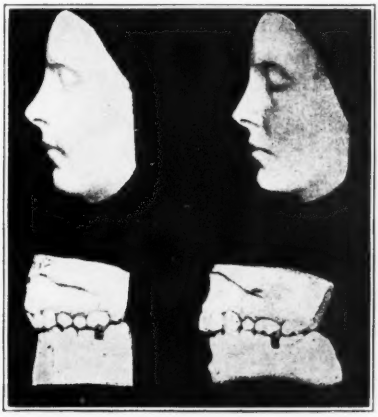

Figure 13.

indeed, if other efficient systems had not been devised with the same desirable end in view, but while it must be and is a great pleasure to all who have known of and practiced the bodily movement of teeth for so many years, to see as last this principle and its benefits so universally recognized and enthusiastically employed, the thought cannot help but arise:—why was it that in all these years, this principle was so completely and even invidiously tabooed, when it was from the very start so generously and so thoroly described in fullest detail and illustrated by many practical cases, proving results?

Why is it that the masses of intelligent, honest, skillful men, those earnest seekers after truth and the most advanced things of orthodontia were so ready to follow without deviation in the foot steps of one who said of this great principle and its methods: "In the opinion of the author, the movement (bodily movement) is of uncertain utility in ordinary practice. It necessitates the use of a complex appliance, obstrusive in appearance, incumbent to the patient, and

Figure 14.

troublesome to the operator. The author believes it wholly unnecessary, for reasons which he gives in the Chapter on Changes Subsequent to Tooth Movement." And with the same apparent undeviating devotion they continued to wait until he, out of his great ingenuity, found a different way by which it is hoped, by us as well as they, that the world can at last receive the benefit of the bodily movement of teeth at the hands of that large class of skilled men who have so recently and enthusiastically awakened to this great and most self evident and well established principle of orthodontia.

One of the recent methods which has

received considerable attention and which I have been given to understand has met with great success, is that originated by Dr. Angle about 1909. (See Fig. 15.) As this apparatus will be fully described and demonstrated in the clinics I will review it only in a general way.

The apparatus was first introduced as a "Working Retainer" in a paper by Dr. Angle, entitled "Bone Growing." Its purpose originally was retention but it was so constructed that the perpendicular posts soldered to the power bow, by being bent slightly forward, then, upon inserting in the mouth, and sprung back into the attachments prepared for them on the anterior bands, could be made to exert a gentle force which was communicated to the roots of the teeth.

It was claimed that the apparatus was so successful in stimulating bone growth that it was given greater scope in its utility and employed to accomplish bodily movement.

There is no question in my mind that it is a very ingenious apparatus and undoubtedly efficient, judging from some of the results I have seen demonstrated. My principal objections to it, however, are the unreasonable length of time required for each adjustment, and inability to estimate the amount of force being applied to the teeth thru the medium of spring of the posts and bow, which must be decidedly uncertain in its action. My natural preference would be in favor of the apparatus which is positively controlled in a moment's time by screw force, altho I have heard it inconsistently stated in my opinion by Dr. Young of New York that while it would probably be impossible to dispense with screw force in orthodontia, it would be very much better if we could.

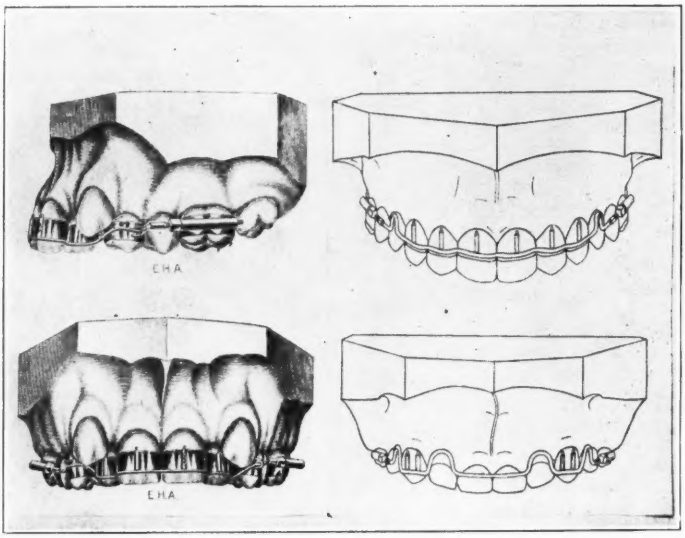

Figure 15.

Fig. 16. A slight variation of this device, introduced by Dr. Robinson a year or two ago but for which he claims no credit, has for its object the lateral bodily movement or tipping of buccal roots.

Movement is secured in the same way as in the Angle appliance, by the pressure exerted by the tortion of the arch bow and posts.

The method which is employed by Dr. V. H. Jackson for moving teeth bodily, which I regret that I am unable to show but with which you are all undoubtedly familiar, resembles in many particulars

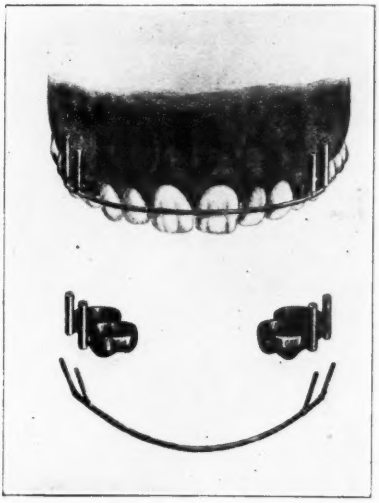

Figure 16.

the apparatus which was commonly known as the "Jackson Crib."

This method differs from others in a marked degree in that spring force, which is quickly regulated according to diagram, is applied to the lingual aspects of the teeth in such a manner that, theoretically at least, there should be in time a responsive movement of the tooth root.

The feature of this system which appeals most to me is the ease with which the apparatus is removed for cleansing and readjustment.

There have been innumerable ingenious methods devised for the bodily tilting or movement of roots of both anterior and buccal teeth; all of them providing, however, for the application of power directly to the tooth crowns and most all depending upon the action of resilient wires.

Fig. 17 is taken from a paper by Dr. Jackson and illustrates one of the few screw devices employed a number of years ago. To each band is attached a rigid bar directly above or below the tube thru which the other bar passes, having a thread and nut at its distal end. If the teeth move toward each other, as they unquestionably must, and the bars do not bend, bodily movement is secured.

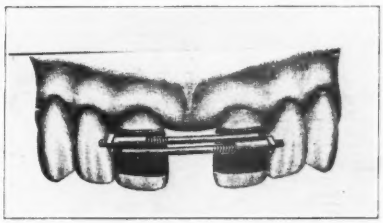

Figure 17.

Fig. 18 shows a method of attaching light spring wires to anterior teeth to effect a tilting movement of roots which are inclined toward or away from each other. It was possibly some form of attachment and spring action similar to this that gave rise to the Angle apparatus, but which covers much more ground by being applicable to four or more teeth simultaneously and capable of producing motion in any direction.

Fig 19 illustrates a comparatively old method of anchoring four incisors together with a close fitting swaged covering which is probably cemented. The lingual bow is locked firmly to the appliance on the incisors and by being sprung upward or downward at the posterior ends, according to which denture it is is applied, force is communicated to the roots of the teeth which must move forward if there is movement at all. This

apparatus might be likened to the Case Retaining Ficture which is employed for the retention of cases in which the anterior teeth have sustained bodily movement, and which will be later described.

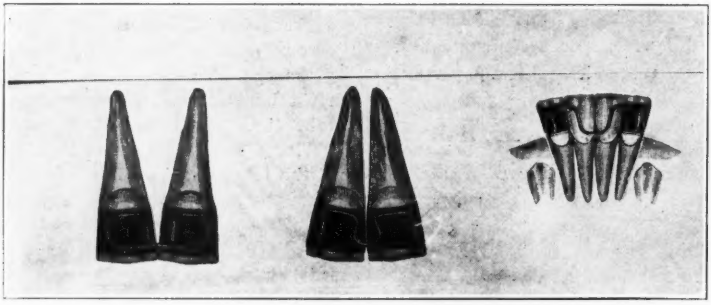

Figure 18.

Fig. 20. One of the few devices employed for moving molars bodily and for correcting the position of molars that are inclining toward, is shown to operate

producing a lateral bodily movement of buccal teeth. In this apparatus, molar or bicuspid bands are equipped with two parallel horizontal tubes. The medium of force is a resilient arch to each end

of which an auxiliary bar is firmly attached as shown, the bodily movement pressure being determined by the radical relation of the bar to the arch.

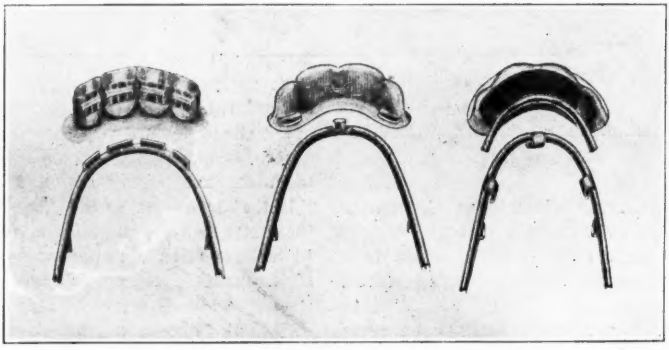

Figure 19.

also with spring wires which seem to me to decidedly inadequate, particularly in comparison with the much more efficient and positive methods of applying screw force which leaves nothing to doubt.

Fig. 21. Dr. Barnes of Cleveland, among others, has devised a method for

Fig. 22 shows another method for producing a lateral bodily movement of buccal teeth which is also dependent upon spring force. The device is unusual, however, in having two separate power bows, one for each side. These are so arranged that when the posterior end of either bow which is bent as shown, is

pressed into its place of attachment upon the molar or bicuspid band, the opposite end stands an inch or more above

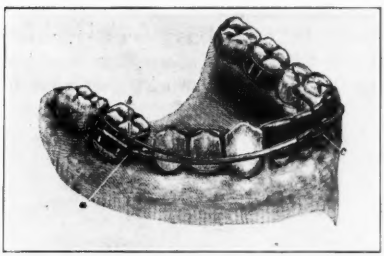

Figure 20.

or below the teeth on that side of the arch as the case may require.

It is intended that when this end of the bow is lifted to the horizontal plane of the dental arch, a tilting pressure is communicated to the roots of the tooth or teeth upon the opposite side where the bow is primarily attached.

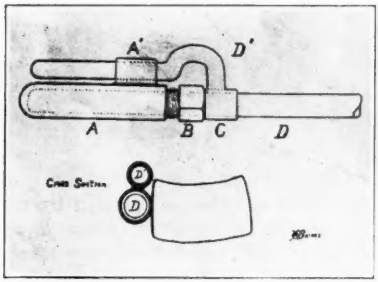

Figure 21.

Fig. 23 shows a method of arch expansion whereby power is applied by screw force as nearly in line with the root apices as the dome of the arch will permit. The buccal bands of this apparatus are equipped with closely fitting plates which answer the same purpose as the rootwise extensions employed on incisor bands in the contour apparatus, to which are soldered rests for the ends of a jackscrew. The apparatus may be rendered more efficient by providing a lingual or a labial

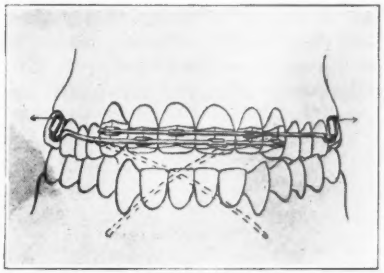

Figure 22.

spring bow with a contracting power to be asserted upon the tooth crowns.

While there probably are other effi-

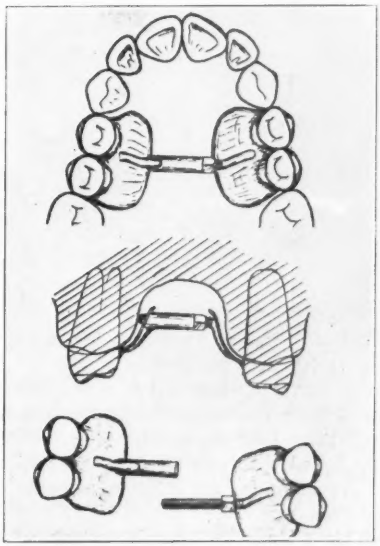

Figure 23.

cient means of accomplishing lateral bodily movement which are equally deserving of credit and honorable mention, I have chosen these few as representative of the principles variously employed.

Probably the first instance in which bodily movement receive any attention so far as practical application is concerned, was in the year 1882. Altho the chronological order of this important event should have placed the review at the beginning of this article, I have thought it advisable to delay it until this

sistance to the movement of the crowns of the teeth.

Fig. 25 shows a device which was conceived during the early practice of bodily movement. Altho this apparatus depends entirely upon rubber elastics for its action, it offers a much greater degree of efficiency even than that applied

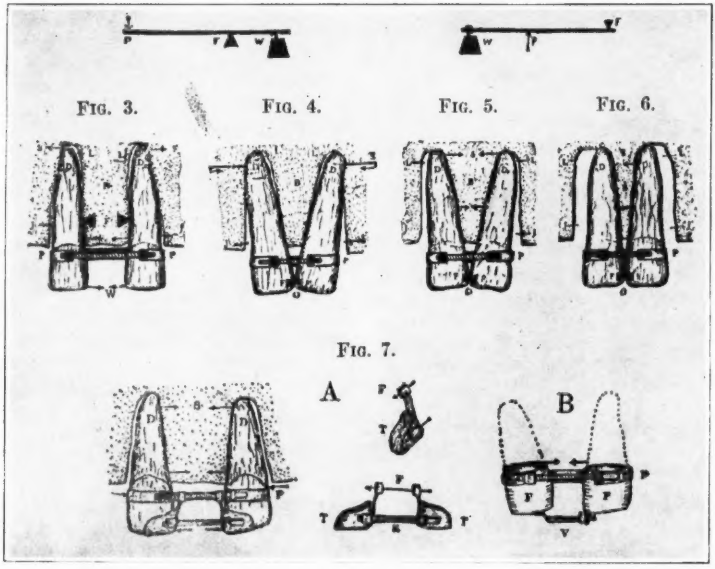

Figure 24.

point as it has an important bearing on the variations which follow.

Dr. Farrar devised and accomplished a method for closing abnormal interproximal spaces between anterior teeth, which was based upon two screw forces acting in opposition to each other as power and fulcrum.

This slide (See Fig. 24) which was made from a reprint in his article, shows the incisor bands equipped each with a tube at its labio gingival margin. These tubes support the threaded bar that supplies the tractive power which draws the teeth together. At the labio-incisal margin is a second screw which offers a re-

by Dr. Farrar which is operated by the more reliable and positive screw force, because of the extended rootwise levers which equip both lingual and labial surfaces of the bands. The teeth under treatment are prevented from passing or overlapping each other by small guide hooks at the incisal margins of one of the bands.

Fig. 26. I have met with considerable success in incorporating these two methods in an appliance used also for general correction of other teeth in the same case, using the screw force of one and the elastic force and rootwise extensions of the other.

The lingual extensions for elastic force application are the same as those in the more simple appliance, while those on the labial surface are broader, being made of plate, and are provided with short tubes which support the traction bar. The crowns of the teeth are prevented from tipping by utilizing the full length alignment bow as a fulcrum.

Since the year 1905 changes have been comparatively few in the common or stereotyped contour apparatus, most of these tending toward greater accuracy and ease of construction. There have been produced, however, due to peculiar and unusual conditions of mal-occlusion which arise and to the many instances which demand the extraction of teeth, a number of unique and interesting variations, some of which will tend to show the wonderful possibilities of this particular system of moving teeth bodily.

In all of these pictures (See Fig. 27) is shown how the rootwise plate is utilized both on the anchorage teeth and the teeth sustaining movement, on the basis that power applied as near to the apical ends of the roots as is consistent with comfort, is much more efficient and receives a quicker and more ready response than power applied to the crowns.

In each of these illustrations it will be observed also how the fulcrum bar is employed to maintain the normal perpendicular of the tooth. In the lower picture, which shows a variation that is applicable in case of loss of second bicuspids or first molars which has permitted the tooth immediately behind to drift inclining forward, the crown of the tooth is held in the same relative position while the roots are being drawn forward, thus placing the tooth in its natural upright position. The application of power from the anchorage teeth, which in this instance are the bicuspids, has no effect in causing their movement on account of the relation which the two forces bear to each other at the point of incidence.

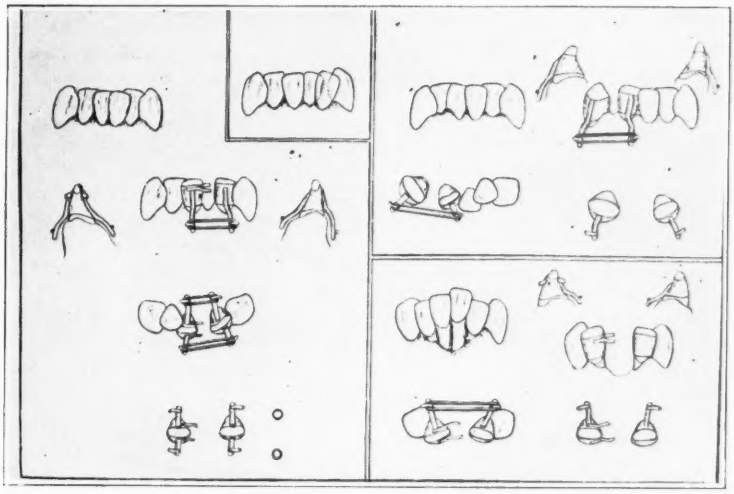

Figure 25.

In connection with these devices I wish to show some common modern methods employed by Dr. Calvin Case for the correction of various forms of maloc-

clusion which occasionally necessitate bodily movement.

The first of these appliances which I shall show is a variation of the regular protruding contour appliance which is especially applicable for the bodily movement of the lower anterior teeth in that type of Class II which is characterized by a dicided retrusion of the entire lower denture.

Fig. 28. In the case in his practice as described by him, which is one of the type I have just mentioned accompanied with close-bite malocclusion—the lower

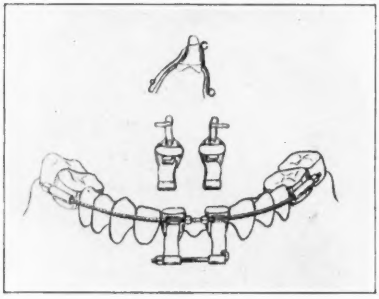

Figure 26.

teeth striking the gum back of the upper incisors, the upper front teeth were forced into arch alignment with silk ligatures, and a six band retainer was placed with attachments for the intermaxillary force. Upon the 1st lower molars were placed crowns to open the bite. The second molars were only partially erupted. To the buccal surface of the crowns were soldered root-wise extensions of heavy plate, to the lower borders of which were attached long bearing tubes for a No. 14 iridio platinum power bow, the force of which was communicated to the labial teeth thru the medium of the usual root-wise bars attached to these teeth.

To the disto-gingival borders of the crowns were attached intermaxillary hooks. Also the buccal surfaces of the crowns were attached the small tubes for the No. 23 fulcrum bow, but which were not employed until later in the operation; the fulcrum bow being attached instead, to the second bicuspids. To these bicuspids were also soldered lingual hook for elastics to hook on to the cuspids. This prevented rotation of the bicuspids, which might have occurred from the force of the fulcrum bow. Root-

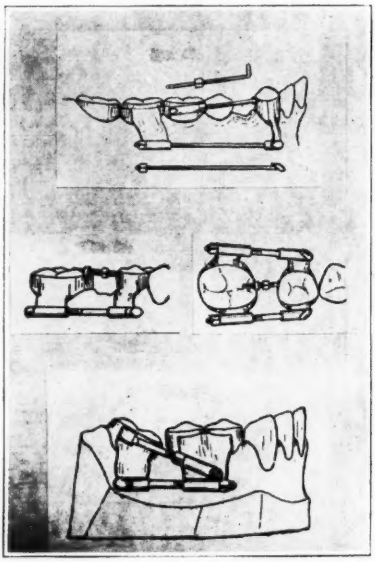

Figure 27.

wise hooks were soldered also to the buccal surfaces of all the bicuspids for extruding elastics leading from the intermaxillary spurs on the retainer to buccal hooks on the upper first molars.

The object of this apparatus, which it fully accomplished as will be shown, was a bodily forward movement of the lower front teeth, and thru the reaction of the necessary fulcrum power the bicuspids were carried equally forward; the intention at first being to open space between the first molars and bicuspids—as in other cases of this character—for the insertion of artificial retaining teeth.

But it was found later when the lower front teeth and bicuspids were nearly in normal occlusion, that the mesial intermaxillary force upon the molars, together with the doubtless very great aid from the erupting molars, overcame the necessity of increasing the power force, and in fact by gradually unscrewing the power nuts, the molars moved forward to a complete closure of the spaces which had been produced, where they continued to remain while the dentures were being brought into a normal occlusion.

In this process the upper retainer, binding the six front teeth firmly together, as has been observed in many other cases, acted as a stationary anchorage to the intermaxillary force, while the elastics to the bicuspids soon lifted these teeth to the new occlusal plane. To this plane also the second molars will invariably grow, or may be aided with the intermaxillary force. The crowns on the first molars are left far into the retaining time. They are employed during a part of the retaining period to support the heavy bars attached to the front retainer, as it has been found to be always necessary where the roots of the front teeth have undergone extensive bodily movement. After the crowns are removed the infra occlusal position of the first molars is soon corrected by attaching the retaining intermaxillary or direct intermaxillary force.

In those cases where the first bicuspids have been extracted a bodily distal movement of the cuspid is often desirable to free the space occupied by the roots, for the retrusion of the incisors and to reduce the prominent canine eminences. Moreover a bodily distal movement of the cuspids without any force exerted upon the incisors will often retrude them, with the entire alveolar process to a surprising extent. Again a bodily disto-mesial movement of buccal teeth is especially demanded after the extraction of the first molars.

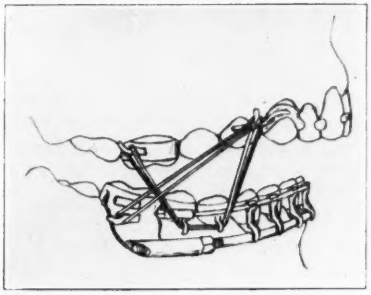

Figure 28.

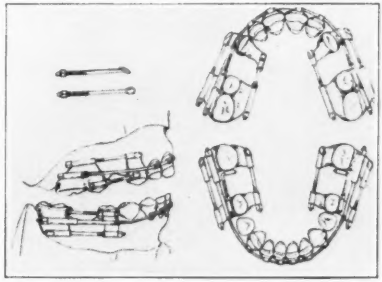

Figure 29.

Fig. 29 is made from an exact duplicate drawing of a recently placed apparatus, for a miss 14 years of age. Its appearance from the drawing would lead one to believe that it is far more complicated, conspicuous, and difficult to adjust than it is. Without the bands on the incisors and lower cuspids and the two retruding bows which are usually not placed during the first three months, the apparatus is hardly noticeable from the front. The patient is now in Europe for about three months. Before leaving she was coached in making the necessary adjustments of the nuts, and there is no doubt but that the treatment will safely progress under her hands.

The case is one of the many bimaxil-

lary protrusions which cannot be artistically corrected without extraction of teeth from both the upper and lower dentures. On the upper the first bicuspids were extracted and root-wise plates as shown were soldered to the buccal and

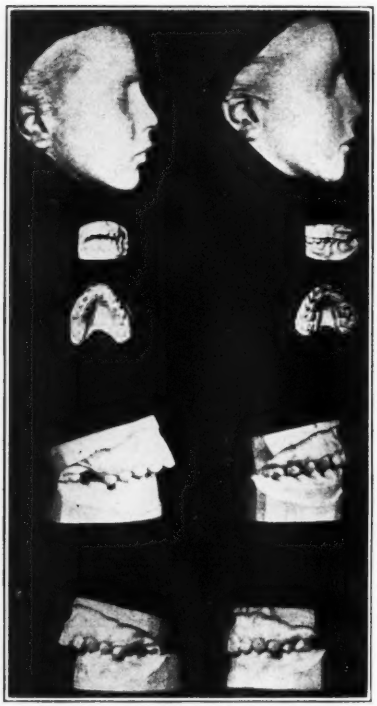

Figure 30.

lingual faces of the cuspids, and the stationary anchorage bands. The tube attachments for the traction power bars should be placed as far root-wise as the free action of the muscles will permit. This is done for two purposes. First to increase the mechanical advantages toward a bodily movement of the cuspids and second to increase the stationary stability of the anchorages. Notwithstanding this root-wise application of force upon the cuspids, there would be no bodily movement at the apical ends of the roots were it not for the fulcrum bars at the occlusal planes to prevent inclination movement. The nuts upon these are gradually unscrewed as the work progresses.

On the lower, as not uncommonly occurs, the first molars were so broken down with decay it seemed advisable to extract them instead of the bicuspids. And as this part of the operation is deprived of the two-band stationary anchorages, greater care in the construction is needful to prevent an inclination movement of the molars which are supposed to move mesially to a certain extent. It differs from the upper appliance in that the retruding bow passes thru telescoping tubes, one of which is soldered to the bicuspid plate and the other to the molar plate. This device aids in keeping the axes of the teeth parallel, one tube passing into the other as the movement progresses.

Fig. 30 was made from the casts of teeth illustrating a case of upper protrusion which required the extraction of an upper buccal tooth on each side. In this instance the first molars were chosen as the crowns were badly mutilated with decay and malformation.

It will be noticeable that altho the spaces caused by the extraction as shown in the casts on the left, are of considerable width, and the relative positions of the second bicuspids and second molars are not particularly favorable, nevertheless these two teeth on each side have been moved bodily toward each other so perfectly that the spaces are not only entirely closed but the roots of the teeth are in harmonious relation thruout their entire length.

Fig. 31 illustrates a case of bimaxillary protrusion requiring extraction. On account of decay the four first molars were extracted instead of the bicuspids and the resulting spaces closed by the methods described.

On viewing the finished models, it will

be noted that the position and shapes of the second bicuspids and second molars show conclusively that inclination or tipping has not entered into the movement in the slightest degree.

Fig. 32. Before drawing this review of bodily movement of teeth to an end, I wish to show a form of retaining fix-

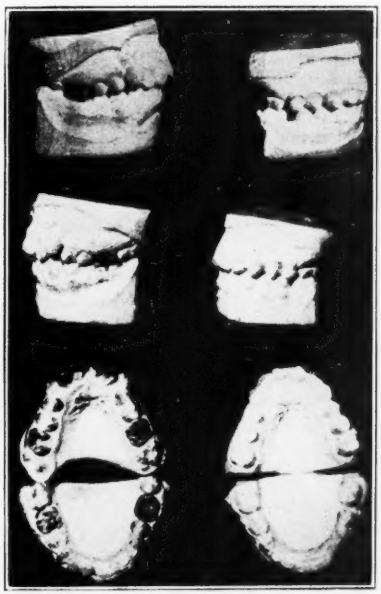

Figure 31.

ture which dates back to the time when it was discovered that teeth which were moved bodily had a great tendency to recede toward their original position and which was extremely hard to overcome. In my opinion it is the only device of its kind efficiently capable of holding anterior teeth which have sustained the disto-mesial bodily movement of roots in the immovable relation which is universally recognized as so necessary to successful retention, altho it has been claimed that all teeth undergoing retention should have at least a small amount of mobility in order that the cellular elements of the surrounding bone might more readily be adapted to the new tooth positions.

The retaining fixture capable of fully sustaining this movement must be one that will forcibly combat the great reacting tendency of the elastic bone and tissue fibres to return to equilibrium. As this force is exerted along the entire length of the root, it must be seen that the stress upon the comparatively narrow zone of the crown which is

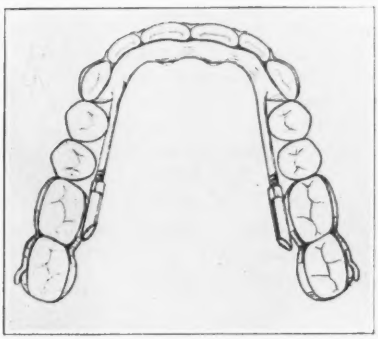

Figure 32.

grasped by the retaining appliance, increases as the force approaches the apical end of the root on the principal that the advantage of a lever of the first kind is increased by lengthening the power arm. Therefore, the necessity is apparent in this character of retention of employing distally extended arms which are exceedingly rigid with firm attachments to the retainer.

The relation which these arms hold to the molar teeth when at rest, is approximately ⅛ to ¼ of an inch above or below the linguo-occlusal plane. It is designed that when these bars, which are threaded at their posterior ends, are pressed into their place of attachment on the molar bands, a sufficient tilting pressure will be communicated to the roots of the retained teeth to overcome

the natural reactive forces subsequent to tooth movement.

In concluding this paper it is a great pleasure to me to acknowledge valuable assistance from Dr. Calvin S. Case, to whom I am indebted for much information and the use of a number of the historical slides which I have been able to show.

Discussions.

Frederick C. Kemple, D. D. S., New York City.

It seems especially appropriate just at this time, because of the very special attention that is for the moment being given to this particular form of tooth movement, that we should have a paper dealing with the "Evolution of the Bodily Movement of Teeth." The subject has also an added interest because it happens to be such a comparatively short time since so many of the same orthodontists who are now so strongly advocating this form of tooth movement were just as strongly opposing it.

Three or four years ago root-movement for patients under twelve or fourteen years of age was regarded by the majority of its present advocates as entirely unnecessary. Nature was then said to correct, thru a normal developmental process, the misplacement of the apices of the roots of the teeth after their crowns had once been brought into correct occlusal relation. Now, we are advised to use root moving appliances on all classes and conditions of malocclusion, and at all ages. The principle has suddenly become one of paramount importance in orthodontia.

In my opinion, this pronounced advocacy of root-movement at the present time is just another instance of enthusiasm running riot with reason. A wise old philosopher has said "there is a soul of good in all things evil, and a soul of evil in all things good." This being true, the present wave of enthusiasm for root movement will probably leave back of it, when it subsides, a contribution to the general good of orthodontia; but at the present time the value of this principle in orthodontia, I believe, is being greatly, even extravagantly, overestimated. In my opinion, fully ninety-five per cent of the cases of malocclusion that come to us under twelve years of age can be easier and better treated by simpler appliances. Many cases can be shown in which extreme conditions of malocclusion have been treated where the amount of tooth movement has been extensive, and yet there is little if any abnormal tipping of the teeth. The method of lashing four or six or eight teeth together rigidly and thus preventing individual tooth mobility I believe to be entirely wrong in principle; and should not be employed except where it is necessary to establish a temporary stationery anchorage for the purpose of producing some other tooth movement. And while the question of root movement may assume a considerable importance in the treatment of adult cases, in my opinion the need of this principle is seldom indicated in the treatment of young patients.

The late Dr. J. Nutting Farrar, I believe, was the first to devise an appliance for moving the roots of incisors and cuspids; later Dr. Calvin S. Case, of Chicago, father of the essayist, improved upon the appliance made by Dr. Farrar, and he also devised appliances for moving the roots of molars and bicuspids; Dr. George C. Ainsworth, of Boston, has also given us an appliance for producing root movement: and more recently Dr. Edward H. Angle has devised and placed on the market an appliance for producing and controlling root-movement. This latter appliance at the present time is attracting considerable attention from orthodontists. The chief difference between the new Angle appliance and those made by the other gentlemen referred to is, I believe, that the new Angle appliance is very delicately made and intend-

ed to produce a slower movement of the teeth, while the others are usually employed in more rapid tooth-movement. All of these appliances bear the stamp of genious and mark their inventors as men of exceptional skill and ability in this line of work.

It seems particularly fitting, in view of the fact that his father has been one of the pioneers in this branch of dentistry, and has been both preaching and practicing "root-movement" in orthodontia for many years, that Dr. Carl Case should have been selected as the essayist to present the paper on this subject.

In reference to some of the statements of the paper: I agree entirely with the essayist that the screw adjustment, in combination with delicate elastic wire arches is the most accurate and satisfactory means of applying force for the movement of teeth.

In describing the use of the appliance shown in Fig. 31 the essayist says: "The case is one of the many bimaxillary protrusions which can not be artistically corrected without extraction of teeth from both the upper and lower dentures." I regret that the essayist did not show the original models of this case. I have been giving considerable attention to orthodontia for the past twenty years and have never seen a case of bimaxillary protrusion that, in my opinion, would justify the extraction of four teeth for its reduction. The essayist refers to this case as being "one of the many bimaxillary protrusions"; if there are "many" bimaxillary protrusions that require extraction for successful treatment I have either been fortunate in not meeting with these complicated conditions, or else I am unable to recognize such cases when I see them.

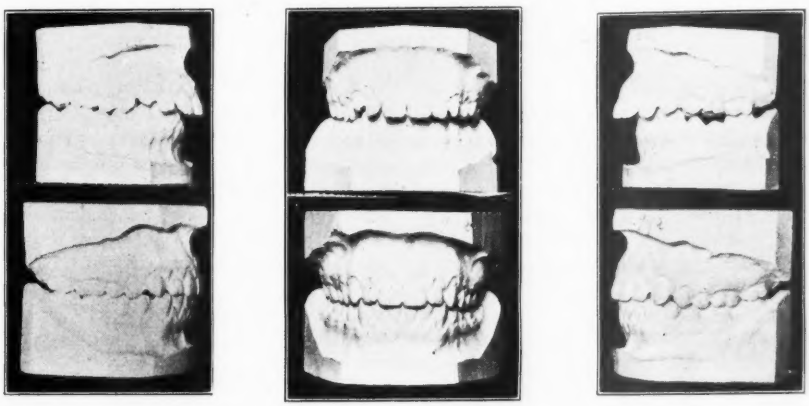

Figure 1.

He also showed, in Fig. 30, the casts of a case in which he considered it necessary to extract an upper buccal tooth on each side. Judging only from the pictures of this case, as shown on the screen, I should venture the opinion that those two teeth were sacrificed unnecessarily, and that a more satisfactory result could not have been obtained by retaining them. The age of the patient was not given, and other factors that I do not know may have decided him to extract in this case—my opinion is based on the casts as shown.

In Fig. 31, the essayist showed casts of another case which he classed as

bimaxillary protrusions. In this case, unless the profile contour of the face of the patient, who was only fifteen years of age, made it absolutely necessary to extract, I would not think of resorting to

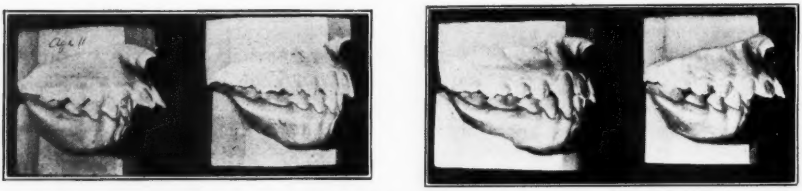

Figure 2.

that form of treatment. The casts in the picture, in my opinion, show no indication of bimaxillary protrusion.

In Fig. 32, a retaining device was shown in which the six anterior teeth were held rigidly in one solid piece, and

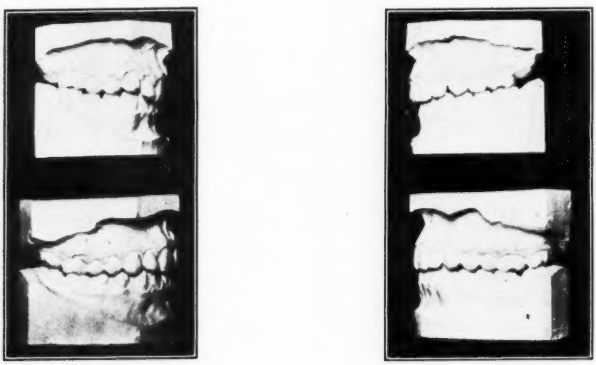

Figure 3.

two molars on each side were held rigidly in bands that had been soldered together. I can not express too emphatically my disapproval of this form of rigid retention for young patients. No orthodontist on earth can, by artificial movement, place the teeth in exactly their proper positions, or move them into an accurate perfect occlusion. He can only place them approximately in their relative positions, but the nice little final adjustments that bring about an accurate beautiful occlusion must all be made by Nature, and if four, six or eight teeth are held in the viselike grip of a rigid retaining fixture, the very end and purpose of retention is defeated.

In my opinion a retaining appliance should be so constructed as to overcome, in the teeth that have been moved, the tendency to return to their original positions, and to allow as much individual mobility to each tooth as is consistant with the accomplishment of this purpose. Such an appliance should be as delicately proportioned as is possible without sacrificing its efficiency.

I have a few slides which might indicate more clearly what I mean when I say that most of these cases do not need positive root movement.

Fig. 1 shows the case of a boy, aged twelve years, in which the teeth are in Class 11 malocclusion (Angle classification) with the upper anterior teeth tipped labially to an unpleasing degree, and

Fig. 3 shows the case of a girl, aged eleven years, in which the relation of the molars and bicuspids has been changed, and space made for the eruption of the left upper cuspid.

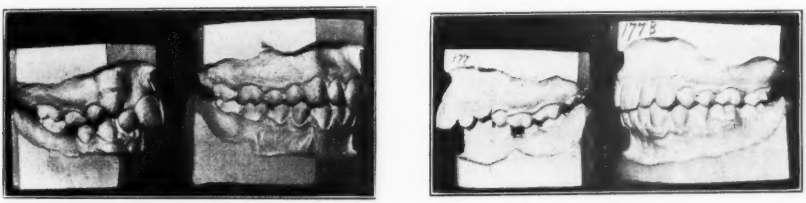

Figure 4.

a very deep overbite of the incisors—the lower incisors striking the soft tissue of the roof of the mouth.

The models in the lower part of the illustration show the corrected position of the teeth, the label tipping of the incisors has been entirely overcome, and the deep overbite corrected. These second models were made about one year after all retaining appliances had been

Fig. 4 shows the case of a boy, about eleven years of age, in which the amount of tooth movement was very extensive—the amount of expansion of the upper arch in the region of the first bicuspids was .29 of an inch, in the region of the first molars .31 of an inch; expansion of lower arch at first bicuspids .20 of an inch, at the first molars .34 of an inch—but the result shows practically no un-

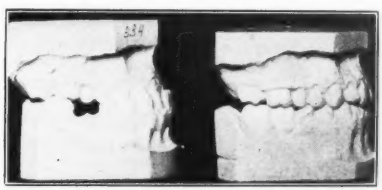

Figure 5.

removed and there seems to be no tendency for these teeth to go back to their original positions.

Fig. 2 shows another case of the same general character, more pronounced than in Fig. 1; patient about twelve years of age; treated in the same manner as case 1 with results as shown in the second set of models, which were made about two years after all retaining appliances had been removed. The teeth show no tendency to go back.

natural tipping of any of the teeth, either incisors, bicuspids or molars, and the occlusion is very satisfactory.

Fig. 5 shows the case of a young lady, age twenty-three years,—the mesio-distal relation of the upper and lower teeth has been completely changed and the result shows very little unnatural tipping.

These cases were all treated with simple appliances, without rigid attachment to any of the teeth, and in most instances no bands in front of the first permanent

molars. My point is this: Why use complicated appliances when simple ones will accomplish the result as well. You can kill a fly with an ax or a cannon ball, but there are easier and more convenient means that are just as effective and not so likely to do other damage.

Dr. Ray D. Robinson, Los Angeles, Cal.

Dr. Case has asked me to take the place of Dr. Mitchell in the discussion of this paper. Unfortunately, the paper was not placed in my hands until it was too late for me to read the paper thru, but I heard it this morning.

In the matter of history, I do believe that Dr. Calvin S. Case is entitled to credit for originality in the use of intermaxillary force, and I believe that, because I have in my possession in Los Angeles, some collateral evidence to that effect.

Dr. Kemple's statement that one cannot get a proper retention by a rigid holding of the teeth, I believe to be correct. Better results can be accomplished in orthodontia by the use of a delicate force constantly applied than by the use of a severe force, intermittently applied. I do not believe that Dr. Young was wrong, when he said to Dr. Case that if the screw could be eliminated and the spring used in its place, it would be better for orthodontia. I believe that the screw can be entirely eliminated in orthodontia. Dr. Case says the spring cannot be controlled. I know it can be controlled.

Dr. Case showed one appliance here in which a 14 gauge iridio-platinum arch was used. I do not believe that a 14 gauge arch has any place in any human mouth. A 24 gauge arch will produce all of the force necessary to any tooth movement if it be properly applied with a proper attachment. I thank you. (Applause.)

A MEMBER: May I ask Dr. Kemple if he has any device which will show some of his small mandibular movements.

DR. KEMPLE: Unfortunately I have no slides with me showing any appliance at all, but I would be very pleased at any time to tell any of the gentlemen anything that I can about that. I have a clinic tomorrow here, and I would be very glad to show you some form of the appliance that I use. These slides are simply a few slides that I happened to have with me at Toronto at the meeting of the American Orthodontists Society. I did not bring any slides to show the appliance at all.

DR. CASE: Gentlemen, there have been a great many points brought up here that it might be well to discuss, but there is one thing that I wish to say at the start—that I had no intention of bringing diagnosis into this matter at all. That was not the object of the paper. It was written entirely from a mechanical point of view, to show various forms or methods of moving teeth bodily, not necessarily the means of determining the diagnosis or determining why that movement should be accomplished but to determine how it should be accomplished. I will say in my defense that as to those bi-maxillary protrusions of which I have spoken and of which I have shown only the teeth models, there was absolutely no question in my mind whatever, and I do not believe there would have been in yours, if you had any artistic sense at all, that those were cases of bi-maxillary protrusions. The protruding upper and lower lips of the African negro are normal to him but are not normal to the white race. Can you imagine such a condition in a member of the white race and then say that it is beautiful and normal? I do not believe the white people who are your patients and who are afflicted with such unfortunate features as prominent negro-like lips, which you can change by dis-

criminately extracting teeth, upper and lower, and in no other way, will thank you if you leave those teeth in. However, that is a matter of personal opinion.

Now, in regard to the heavy bows used in this appliance. I do not know why Dr. Robinson should have taken it into his head to say that simply because those bars are of such large size that the force must necessarily be so extreme. Bars were used of that size to keep them from bending in any particular. The force was applied so easily and quietly that the patient never even knew when the force was applied, so far as pain and soreness were concerned, and I think we are justified in claiming that the force which is applied by screws can be a great deal more readily estimated than that applied by a spring. However, again that is a matter of personal opinion.

So far as retention is concerned, again we have a matter of personal opinion. These retainers we have used for the past twenty years. Ever since the contouring appliances were first invented and used, those retainers have been employed and they have proved very effective and lasting results can be seen in almost every case. I regret exceedingly that I had not thought to bring face models showing the conditions I have described. To my mind the evidence would have been conclusive.

Again, the extraction of teeth really has no part in this paper, so far as diagnosis is concerned, but I wish to say honestly that I cannot quite believe that any man in our profession is so lacking in the sense of facial proportion, harmony, beauty and symmetry that he will refuse to extract teeth for regulating purposes or will insist upon retaining all the teeth in the mouth because God put them there or because of certain teaching prevalent during the last twenty-five years. I thank you. (Applause).

THE PATHOLOGICAL SIGNIFICANCE OF IMPACTED AND UNERUPTED TEETH.

By Chalmers J. Lyons, D. D. Sc., Ann Arbor, Mich.

(Read before the National Dental Association.)

IN A PAPER on the subject of "The Dental Relationship of Arthritism" read before this association a few years ago, Dr. Edward C. Kirk made this statement:

"In the study of disease phenomena there is an ever increasing tendency to investigate more deeply into the underlying causes of the many departures from normality which constitute the "ills that flesh is heir to." At no time in the history of the healing art has the search for the remote causes of disease been more active than at the present, and as a result of this persistent investigation the prospects of a rational solution of many of the grave pathological problems grows continually brighter."

Several years have elapsed since these prophetic words were written, and thus far, in response to this persistent investigation after the truth, many of the great pathological problems have been solved, and the rational solution of many others is well on its way to successful culmination.

The medical scientists are working hand in hand with the dental scientists in seeking out the solution of many of the great problems of health and the medical men are looking to the dentists to give the public the answer to some of these great problems.

Until recently there has existed among physicians, not only a disregard, but a distinct, tho possibly a mild, dislike of the teeth as organs to be reckoned with medically, they were ostracized so to speak, and not to be admitted to their pathological birthright. Until recent years few systematic attempts have been made to connect the disorders of the teeth with the sufferings of the human race, except for the most obvious phenomena of pain, or a direct association of cause and effect. In other words the teeth were only recognized when the source of irritation and the seat of pain were in the same region, and the teeth were obviously the irritants.

Ordinary pain at distance, such as headache, neuralgia, or other nervous disturbances, due to the teeth, were generally disregarded, and, indeed, today the writings along this line are very few and none are comprehensive.

Clinical observations of the writer, as well as that of others, have demonstrated the fact that the impacted tooth, or the less frequently appearing unerupted tooth which apparently may be lying harmlessly dormant in the human jaws, are to be reckoned with, not only as a direct association of cause and effect, but also as an etiological factor in many of the nervous disturbances and other ills which afflict mankind.

The teeth, particularly unerupted ones, have for years been recognized as etiological factors in the production of neoplasms effecting either the upper or the lower jaw, but in spite of this fact, little attention has been given to the subject by writers upon surgical topics.

This lack of literature has perhaps led to misapprehensions regarding diagnosis and treatment and conservative methods which would result in benefit to the patient, have too often given place to uncalled for radical operations, obviously detrimental to the comfort and appearance of the patient.

It is to some of these pathological conditions that the writer desires to briefly call to your attention today.

The etiology of impacted teeth can in a measure be accounted for. A tooth is said to be impacted when its eruption is partially or wholly obstructed by bone or by some other tooth. The teeth most frequently impacted are the lower third molars.

Probably the best theory of the etiology of the impacted lower third molars is given by Tomes.

He says "the third molars being the last to take their place in the series are, from obstacles opposed to their eruption, a frequent cause of suffering. The second molar immediately in front, and the terminal point of the alveolar line behind, bound the space accorded to the third molar. Each tooth which has no deciduous predecessor is developed beneath the base of the coronoid process in the first instance and as the coronoid process recedes by absorbtion on its anterior and deposition on its posterior surface the tooth is enabled to come into its proper position, but, if the backward development of the maxilla has been arrested the interval will be insufficient for the normal arrangement of the presenting tooth.

The cuspid teeth are the next in the series of teeth most likely to be impacted. The etiology of this condition can be accounted for in a general way in the same manner as that of the lower third molar, viz: by insufficient space for the normal presentation of the tooth. This tooth in making its normal appearance long after the lateral incisor has erupted, and some time after the eruption of the first bicuspid, meets a condition in which there is not sufficient space between the lateral incisor and the first bicuspid for it to take its normal position in the arch, and a resultant impaction occurs.

While the lower third molar and upper and lower cuspid teeth are inclined to impaction more frequently than any of the other teeth, yet any tooth in either arch may become impacted if the environments are not such that normal eruption can be made possible.

The impacted tooth usually takes an oblique direction, either forward, outward, inward, or backward.

Two distinct conditions must be recognized in accounting for the malposition caused by the impaction.

1st. The tooth in pressing forward has taken a direction in which the least resistance was offered to its progress. 2nd. The malposition has been assumed at a comparatively early period, of development irrespective of resistance at the time of eruption.

When any physiological process is interfered with, sooner or later a pathological condition may arise.

Probably the most common and perhaps the most prevalent disturbances we have to encounter in conditions of impaction are local infections of the soft tissues surrounding the teeth, particularly is this true with the impacted lower third molar.

The gum tissue is forced over the bucco-occlusal surface of the tooth and during the process of mastication becomes bruised by the teeth of the upper jaw. In such conditions inflammation of the gum is set up and maintained. This inflammation seldom limits itself to the parts injured, but more commonly extends to the adjoining parts, involving the soft textures about the ascending remus and fauces.

The acts of deglutition become painful and the motions of the jaw restricted. After a time the gum suppurates and the

movements of the jaw becomes less constrained. The patient may have recurrent attacks of the same character at frequent intervals until conditions are restored to normal by surgical proceedure. Another pathological condition which sometimes occurs as a result of the impacted lower third molar, is pressure resorbtion of the second molar. The pressure exerted upon the distal surface of the second molar by the occlusal or mesial surface of the impacted tooth in its effort to erupt will sometimes cause a resorbtion of the distal surface of the second malor. This may become so extensive that the nerve pulp of this tooth is encroached upon and a direct irritation of the pulp is set up. This condition is also manifested in the impaction of any other tooth of the series. It seems to be a physiological fact that when any abnormal pressure is brought to bear upon any of the tissues of the human body resorbtion of that tissue immediately begins, so, when an abnormal pressure is brought to bear by one tooth upon another, the surface which has the least resistance will be subject to the physiological process of absorbtion.

A more serious condition may arise from the impacted lower third molars by pressure being exerted upon the inferior dental nerve. The root development of these teeth may cause infringement of the root upon the inferior dental canal. When this condition is present the pain is quite as likely to be expressed in some other part of the head as well as in the region of the offending tooth.

The impacted lower third molar is probably the source of more conditions of referred or reflected pain than is manifested by any other organ of the mouth or jaws.

In the light of our present knowledge we do not know exactly the nature nor etiology of this pain. Much has been written on the subject but it is still largely a pathological mystery.

Many theories have been formulated in attempting a solution of reflected pain but none are entirely satisfactory.

Perhaps one of the most plausible theories regarding the phenomena of referred pain is the one advanced by the German scientist Goldscheider. He has done a considerable amount of research work along this line. In his collected works he expresses the opinion that pain of this nature is caused by two nerve fibres leading from the same nerve cell; thus when the source of irritation is in one part of the body and the seat of pain is expressed in another, possibly remote from the source of irritation, Goldscheider believes that the impulse of pain is conveyed to a nerve cell with two nerve fibre leading from it and the brain may interpret the seat of pain at the nerve endings of either nerve fibre. The nerve endings of one fibre may be quite remote from the nerve endings of the other as in the trifacial nerve, one fibre may be in the opthalmic division of the nerve and the other fibre in the maxillary or mandibular division, with their nerve cell in the Gasserian ganglion. Thus the source of irritation may be in one division and the seat of pain in another.

As a practical illustration and one that occurs frequently in connection with the impacted lower third molar; this tooth becomes the source of irritation which is in the mandibular division of the fifth cranial nerve, the seat of pain may be expressed in any part of the head or face which is supplied with sensation by this nerve, as for example in an upper tooth the antrum of Highmore or the orbital region, the brain, apparently is unable to correctly interpret the source of irritation.

The practical lesson to be derived from this, is, that when cases of seemingly obscure pain present to the dentist, the

lower third molar should always be suspected as the source of irritation. If they are not in normal position the radiograph should be resorted to as a means of aiding in the diagnosis.

The late Dr. Henry S. Upson in his book on Insomnia and Nerve Strain ascribes the causes of many of the nervous disorders, such as insomnia, melancholy, epilepsy, etc., to impacted teeth, and in co-operation with Dr. John Stephan, of Cleveland, has reported a number of cases as much beneficial after their removal.

He states that certain types of nervous disturbances caused by dental impactions has almost the clearness of a labratory experiment, as in it the severest symptoms are set up by the the simplest irritant. Pains may be from the beginning to the end quite lacking.

It is the constant tho mild irritation, perhaps not sufficient to produce pain, that sets up some of these nervous disturbances, which may of themselves take on a violent form.

The writer has observed four cases of epilepsy where there has been no return of the trouble after a period of eighteen months following the removal of the impacted third molars. Whether the impacted teeth were the whole etiological factors in these epileptic conditions, or only secondary it is difficult to state. In only one out of the four cases was any further treatment followed and in this case bromides were given, but the attending physician gives credit for the immunity from the nervous disturbance, to the removal of the impacted teeth.

It is not to be thought of for one moment that all cases of epilepsy may be benefited by the removal of impacted teeth.

Neither can other forms of extreme nervous disturbances be benefited in every case by their removal.

The writer believes, however, that impacted teeth should be considered as a possible etiological factor in the diagnosis and treatment of many of the obscure nervous diseases wherein the trifacial nerve and its many ramifications may possible be involved.

In some cases of impacted third nature molars the acute inflammatory conditions may be of such a violent nature that the operation for their immediate removal will be contra-indicated.

Quoting from Brown's Oral Diseases and Malformations, he says, "It may be apparent that the tooth must be removed but the time of operating is a matter of much importance. A number of deaths have been recorded from immediate operation upon cases during the acute inflammatory stage." He says further and the writer's clinical observation coincides with the statement, that "the presence of micro organisms in the blood appears to have demonstrated that the opening of blood vessels incident to operation for the removal of impacted teeth has allowed the direct entrance of septic matter into the circulation and converted septic intoxication into true septicemia."

Many other pathological conditions might be mentioned where impacted teeth are the etiological factors such as necrosis abscesses, etc. Recently a case of Ludwig's Angina was reported where an impacted lower third molar was determined to be the source of irritation.

Time will not permit to go into further details relative to pathological significance of impacted teeth, and we will pass on to some of the abnormal conditions which arise from those teeth, which from one cause or another fail to erupt and which may lie dormant for several years without any outward disturbance, and suddenly take or become associated with an active pathological condition.

If we knew the etiology of the eruption of teeth, we could then possibly make a definite statement as to why teeth frequently do not erupt. Hopewell-Smith in his book on Dental Anatomy

and Physiology says, "The process of the eruption of the teeth is a physiological mystery as is that of growth generally."

There have been many theories advanced for the solution of this phenomena, but all these seem to have some objections.

We do know, however, that frequently certain teeth in the jaws fail in this physiological process and in many cases certain pathological conditions arise germinating directly from these teeth which are retarded in their eruption.

There seems to be some relation between unerupted teeth and impacted teeth. Those teeth which are most frequently impacted, that is the lower third molar and the upper cuspid, are the ones that are most frequently found in other individuals to be the teeth whose eruption is retarded.

Tomes is of the opinion that in cases of retarded eruption of special teeth there is no interuption in the process of the devolopment of the dental tissues.

It is true the roots may be slightly shorter and may be somewhat malformed but according to Tomes, this does not prove that the development of the tooth was delayed.

In certain cases the obstruction cause may produce an impaction and prevent eruption but in other cases when there is no obstructing cause and still there is retarded eruption, the etiology remains a pathological mystery.

The pathological significance of unerupted teeth has too often been overlooked in the diagnosis and treatment of dental diseases. Today, when such free access to the radiograph can be had, there can be no excuse for the dentist or surgeon not to have exact knowledge of the whole situation and condition previous to an operation. Then an operation may be made a benefit to the patient rather than one which would impair his future comfort and happiness as is too often done.

As a striking example of some of these uncalled for radical operations when the source of irritation was not recognized by the physician or dentist, a history of a case we have recently operated will perhaps not be out of place.

Mr. D.————, age 38, presented with extreme pain on right side of face. Jaws in state of partial ankylosis. Pain has been severe for one and one-half years. Had treated with several physicians for neuralgia with no appreciable benefit. After six months of severe pain had all the teeth removed on right upper jaw from right third molar to and including the right central incisor. Six months later still suffering severely, had right lower bicuspids and first and second molars extracted without and appreciable relief; some time after the removal of the lower teeth a radiograph was made of the jaws and an unerupted lower third molar was discovered. This was found to be the source of irritation. An inflammatory condition of the tissues existed which no doubt was causing pressure upon the inferior dental nerve and by the phenomena of reflected pain was causing the severe symptoms indicated.

The tooth was removed and the case followed up with post-operative treatment for several days and the patient discharged from the hospital entirely free from any of the former symptoms.

Thus nearly a dozen teeth were sacrificed needlessly and the patient had to undergo almost an endless amount of suffering thru the lack of conservative methods of treatment.

It is a remarkable fact and one which has not yet been sufficiently explained that unerupted teeth after having lain quietly for years in the jaws, suddenly become the seat of purulent inflammation with sometimes serious symptoms.

In this connection Prof. Dr. Williger of Berlin, reports an interesting case of inflammation being set up by resorbtion in an unerupted cuspid. The patient was

a young man about nineteen years of age. After the tooth was removed, it was subjected to a histological examination and it was determined that resorbtion of a portion of the root had taken place. He states that in this case the tooth was not subjected to any pressure from an erupting tooth which from a physiological standpoint, would cause resorbtion of its roots. He says, "We can assume that the displaced tooth like a foreign body, has fallen prey to resorbtion and that the phenomena of resorbtion in retained teeth are subject to certain physiological laws which future investigators may be able to furnish us with a satisfactory explanation."

He concludes "That the possibility of infection from the blood passages in such cases must not be overlooked; as in the tortuous long passages which the resorbing tissue forms in the dentine of retained teeth a retardation of the blood streams is very easily conceivable. In this was a suitable place for the embolic attachment of bacteria is afforded, and inflammatory diseases may ensue."

In certain cases of unerupted teeth where an irritation has been set up and purulent inflammation has become seated, a bone abscess may form around the region of the unerupted tooth, a long fistulous track is formed along the line of least resistance for the discharge of pus. This abscess may develop until a large portion of the jaw becomes involved.

As a concrete example, Mr.——age 32, a Belgian, complained of pain on right side of face, when he was crossing the Atlantic enroute to America. He did not procure medical services until he landed, at which time he was told he had an abscessed tooth and advised to have it removed. His teeth showed no sign of caries, and the dentist whom he consulted on his arrival advised against the removal of a sound tooth, but did not suggest the cause of his trouble. Fourteen weeks after his trouble was first noticed the abscess had formed a fistula along the sternomastoid muscle and opened just above the clavical. A radiograph of his head was obtained, and an unerupted lower third molar was discovered lying just distal to the apical end of the roots of the second molar. By this time the abscess had involved all of the distal portion of that half of the mandible and after a conprehensive operation the tooth was removed and in time repair has taken place. If a correct diagnosis had been made early, much suffering and annoyance to the patient could have been saved. This correct diagnosis could have been made if these obscure pains had been run down to their source at once instead of waiting until the abscess had formed from the unerupted tooth.

One other pathological condition may be mentioned which is associated with those teeth whose eruption is retarded, and that is the cystic growths which are connected with the teeth.

Broca states that "the great majority of cysts of the jaws have their origin in tooth follicles."

Oliver in the Annals of Surgery says that "misplaced and inverted teeth have been the apparent starting point of Neoplasms and cysts, but little is known of the exciting causes of the condition."

Tome explains the formation of Cysts in connection with retained teeth, he referring to the fact that when the development of the enamel of the tooth is completed, its outer surface becomes perfectly detached from the investing soft tissue and a small quantity of transparent fluid, not uncommonly collects in the interval so formed. This fluid, ordinarily, is discharged when the tooth is erupted, but when from some cause the eruption of the tooth is prevented, it increases in quantity and gradually distends the surrounding tissues, in the form of a cyst."

Other theories for the solution of the cause of these cysts have been advanced such as irritation from the unerupted tooth, failure in Evolution of the tooth, etc., but all seem to meet with some objections. There are certain clinical facts however, which are of vital interest to the dentist.

1st. These cysts are associated with unerupted teeth.

2nd. The vast majority of examples of this affection occur in patients under thirty years of age.

3rd. These growths occur at or shortly after the period, when the affected tooth should under ordinary circumstances be erupted.

4th. All unerupted teeth are by no means associated with cysts, but they should be held in suspicion.

These are points that must be taken into consideration, then in the recognition of the real nature of these growths. The diagnosis should be made just as early as possible and treatment proceeded with.

It may be superfluous to state that the etiology of many of the pathologic conditions arising from impacted and unerupted teeth is somewhat obscure, yet these conditions exist and are responsive to treatment. It behooves the dentist, then, to be on the alert in noting symptoms indicative of these conditions so that he may make accurate and positive diagnosis. In doing so he will be in a position to treat his patients in a more intelligent and successful manner and thus encourage and promote desirable professional relations with medical practitioners.

Discussions.

Dr. Thomas Hinman, Atlanta, Georgia.

Mr. Chairman and members of Section II: The contribution of Dr. Lyons is a most valuable one to our literature, particularly on this subject. It is a subject that I have paid some little attention to and have made a few observations along the lines of impaction and particularly along the lines of infection. It has been true that in the past the medical profession have not thought the impaction of the teeth a source of general disease; neither have they thought that infected areas in and around the teeth were a source of a foci for general systemic disorders, but I am glad to see, due to the work of our profession and particularly to the work of the National Dental Association and its research commission, that knowledge is being distributed and the medical profession are grasping it and reading it greedily, and that in our city cases are constantly being referred to members of our profession where the cause of systemic disorder cannot be located by the physicians. This is a source of gratification to me individually, and I know to the members of the profession in my locality.

The lack of literature on impactions and that problems that follow it is well known. I am not familiar with the literature spoken of by the essayist, but our own literature is so meager that about the only thing we can get is a copy of a a good many radiograms of impacted teeth and very little of the pathology of this subject is understood.

The impaction of which I will speak particularly is that of the third molar. This seems to give the greatest amount of secondary trouble. In my experience I have never seen anything but neoplasms and cysts that have come from impactions to the cuspid teeth, but I have seen reflected pain and severe reflected pain from the impaction of the lower third molar. One of the most fruitful sources of constitutional infection comes from the infection located around an impacted third molar. The essayist speaks particularly of reflex pain. I wish to speak more particularly of the cul de sac around the unerupted or partially erupted third molar as a foci for general infection. It is my belief in my practice that whenever there

is a cul de sac formed by the soft tissues, and food packs in there and we get infections, it is better to remove this tooth, because in so doing we are able to remove from that person's system a foci of general infection that might result very disastrously to the general health of the patient.

My attention was first called to pressure resorption of the lower second molar by pressure from the lower third molar in a case that was presented in my practice six or seven years ago. The patient had suffered intensely for several years and no relief had been obtained. In examining the mouth, we found the second molar in position, the pulp having been destroyed. There was no evidence whatever of a third molar. A skiogram was taken and a lower third molar discovered, but pressure resorption had taken place, the third molar had gone completely into the pulp chamber of the second molar, the pulp had become exposed and the previous operator had devitalized the pulp, which gave relief for a short time. In a short time the pain returned. After the tooth was removed we found in the third molar decay had taken place and we had exposed pulp in the lower third molar, which was absolutely unerupted. That was the cause of severe neuralgic pain.

The involvement of the pulp is one thing that we must pay particular attention to in pressure resorption. A case recently came under my observation where the roots of the impacted third molar was pressing on the anterior dental nerve, the roots penetrating the canal. In this particular case there was very severe neuralgic pains and a considerable loss of weight by the patient. He became quite emaciated from the continued pain.

The question of reflected pain, of course, is a very difficult one for us to solve, but we do have these reflected pains. This man in particular, where the lower molar was impacted and the roots pressed on the interior dental nerve, the excessive part of his pain appeared at a focus just above the right shoulder.

Upson has done some wonderful work along the line of the relation between impacted teeth and mental disturbances. I was very much interested in the result obtained by the extraction of impacted teeth and that apparent cure of epilepsy. The question arises in my mind in that case, if there was a bone abscess, in infected area, wouldn't it be possible that the blood stream being poisoned by this infection and a general toxemia taking place, that that in turn might cause a disturbance known as epilepsy, about which little is known scientifically? Isn't it just possible that the blood, not having the power to throw off the infection, and the infection becoming greater than the anti-bodies, just exactly as in malaria? Just as we get the change in temperature in malaria, isn't it possible that this same change might take place in the brain?

There is one particular thing to which he calls our attention that I consider as extremely important, and that is treatment at a time when there is an acute inflammatory condition. We should pay particular attention to this. There is just one thing which I regret about this paper, and that is, that Dr. Lyons has not given us his technic for the removal of impacted teeth, which I consider superior to any technic of which I have knowledge. His case records are exceedingly interesting and worthy of our very close observation and attention. In general, let me thank the essayists for a most excellent contribution to literature on this subject. I feel that it would be a great privilege to work with him for awhile in the clinic of which he has charge. I thank you. (Applause.)

Dr. F. B. Moorehead, Chicago, Ill.

Mr. Chairman and members of the section: I want to say just a word

before discussing the paper intimately about the position of the dentists. Dr. Lyons mentioned in his paper, Dr. Hinman mentioned it in his discussion, and it has been mentioned on this floor several times. That is, the combatant attitude of the dental profession toward the medical profession. That is never going to take us any place and we are making, I think, a very serious mistake. Whenever we have progressed to that point where there is no fault to find with our work, then and then only are we warranted in attacking the medical profession for inefficiency in their work. (Applause.)

I happen to stand in juxtaposition to both of these professions. The man who is in the practice of oral surgery has relations quite as intimate to the one class of men as he has to the other and is in position to know something of the merits and demerits of both types. The physician is to be criticised and so is the dentist, but I do not think there is very much choice between the two types of criticism, and, if we are to solve the questions which have been placed upon us, we will solve them very much better and very much quicker by working together in harmony than by standing in a 24-foot ring with 4-ounce gloves on our hands. (Applause.)

There is much to be done and we need each other so badly and so often that enmity is not going to help us in our work. We must stand in harmony and the less we criticise each other the better it will be for both of us, because we both are subject and liable to criticism, and I suppose we deserve it.

Back of this whole thing is that human quality of selfishness, which is at the bottom of it all. You say the physician oversteps the bounds. So does the dentist. They say the dentist oversteps his bounds. So does the physician. Who is the worst offender? It is selfishness on the part of the general surgeon that he does oral surgery; otherwise he would not do it. And whenever you can rule out that element of selfishness you will have solved many of the difficulties which men face in all walks of life today in medicine and in dentistry, but as long as men continue to be selfish just so long will they do things which they ought not to do and leave undone things which they ought to do. The combined effort on the part of the physician and the dentist will take us a great deal further along the road toward that field of happiness than we will ever get if we stand at the bottom of the hill and fight until we are tired out. Now let us avoid this antagonism, this combatant attitude. It is easy to preach, you know, so I am preaching for the moment. (Applause.)

Now, a word as to the far-reaching effect of an irritant, such as an impacted or unerupted tooth. You can not tell what is going to happen to the growing boy or girl who has an unerupted tooth. In the one case there may be no great apparent disturbance. There may be apparent to the trained eye even nothing of importance. On the other hand, there may be a tremendous impact made on the general physiological balance of that boy or girl, man or woman.

We have two attitudes in this thing Dr. Lyons is talking about. We have the attitude of the scientist or pathologist, the attitude of the man who is interested in seeing things and doing things in the particular field; but there is back of all of that, if we are to succeed in life either as dentists or physicians, another attitude which is paramount, and that is the human attitude, and the man who has a lot of humanity in him plus a scientific viewpoint is the man who is going to do the greatest amount of good in the world. And if we can, in facing these cases, think of the possibilities of a boy or girl under one condition over against another condition, our attitude toward that individual is going to be entirely different than if our attitude toward that

individual is purely that of a pathologist or a "simon-pure" scientist. For instance, a boy fifteen years of age comes to you. He has been at loggerheads with his school teacher, with his father, with his mother, and with everybody in general. He is what is called a bad boy. He fails in his examinations. He is sent from one place to another. He has been to his principal's room; he has been sent home; he has been flogged at home; he has been sent back to school, and he goes from pillar to post until finally he becomes what the sociologist calls a delinquent, and this whole country is full of delinquents, men and women. Now, the delinquency of that boy may be due to the most apparently insignificant and slight irritants of a physical nature, and if somebody had found and removed it at the proper time, he might, instead of being a delinquent and a charge upon society be a man of efficiency and responsibility in life. And that is the human attitude that we ought to take toward all of these patients.

The difference between a man who is thoroly comfortable and a man who is physically uncomfortable is a vast one. No boy or girl is efficient who is uncomfortable, and these things make boys and girls and men and women uncomfortable and destroy their greatest usefulness in life.

I say that you cannot measure the far-reaching effects of an irritant. An impacted or unerupted tooth may even to the trained eye cause no observable trouble. On the other hand, grave things may be attributed to it. You cannot tell what a man might have been if he had not had even the simplest impact made upon his physiological balance, upon his whole nervous mechanism, and simply because we find people with impacted and unerupted teeth at 50 years of age and the patient has not shown that he has had in his jaw an erupted or impacted tooth does not mean that there has not been an impression made upon that man's physical economy of greater or less magnitude, and it is not enough to say that the man is perfectly strong, healthy and well even tho he carried about with him an unerupted impacted tooth.

As to this question of reflected pain, we all have had sufficient clinical experience to know that irritation at any point of the nerve trunk may produce pain in another point to which that nerve trunk or its branches may go. The exact explanation for this would be exceedingly difficult to make, except this: We know this to be true, that the nerve trunks of the sympathetic nervous system have no insulation and thru them impulses may be transferred even by tissue contact from one nerve trunk to another. An impulse set up in a sensory or motor nerve trunk must, of course travel along the current of that nerve, but the impulse set up in a sympathetic nerve may go from one to the other, and many of our referred pains must be explained on the basis of the operations of the sympathetic nervous system in its relation to the cranial and cerebral nerves.

Another thing that ought to be borne in mind in this discussion is the question of pain habit or psychic neurosis. I believe there is such a thing as pain habit; that there is such a thing as psychic neurosis. Given the case of a patient who has had an irritation for a long period of time, and if the removal of that irritation will not relieve that individual of his discomfort or his trouble, there has been established there an anatomic or a physiological derangement of the tissue, which leaves the patient below par. To be sure, in a majority of cases where you remove an impacted tooth or remove an irritant of one kind or another the air is clear, the patient is comfortable, he is entirely well. In other cases, you do these things and the patient continues to complain of pain, and despite the most painstaking thoroness

of your diagnosis and investigation you can find nothing to which you can attribute his discomfort. That must be put down as pain habit or psychic neurosis. You say that is begging the question? It is not begging the question. Clinical experiences on the part of eminent neurologists have developed the fact that there is such a thing as pain habit, that there is such a thing as psychic neurosis. You say it is in the man's mind. It might just as well be in his big toe. If it is there, it is there. It don't make any difference, so far as that individual is concerned, so far as his future is concerned, so far as his usefulness is concerned, whether that be a psychic condition or whether it be a physical lesion, the fact remains just the same. That man is not a useful citizen.

Again, every impacted tooth is potentially a menace to every patient who carries it about, because they are most likely to become a seat of infection at some time or other. For that reason every patient who has an impacted unerupted tooth ought to be urged to have that tooth removed, either brought down in place by the orthodontist or removed entirely. I believe you cannot impress that too strongly.

I am not going to go into this question of the lower third molar because it is too big. There are lots of things I would like to say about the third molar, but I am not going to specify it any more than any other impacted tooth. In the removal of the lower third molar or any other impacted tooth, the man who does it ought to exercise the greatest care, because there is a possibility of inflicting so much trauma in the removal of this tooth that you will have a condition almost as bad as the patient was in before it was removed. There is the possibility of injury to the periosteum which will result in periostitis, and that is one of the meanest things we have to deal with. In the second place, principally in the lower jaw, there may be injury to the inferior dental nerve. I have seen a good many cases, and you have too, where teeth have been removed by methods perhaps not wisely selected, and in which injury was done to the nerve trunk which leaves the patient to suffer for life because of large trauma or direct injury to the nerve trunk at the time of the operation. The removal of an impacted third molar is not a boy's job; it is a man's job, and must be approached with a good deal of care. The dentist of today should be able to examine every mouth with which he comes into contact and be sure that he recognizes these lesions and then in a careful and scientific manner remove them. I thank you very much. (Applause.)

DR. JOHN SAYRE MARSHALL, of California:

Mr. Chairman, ladies and gentlemen: I have been very much interested this afternoon in listening to the paper and also to the discussion which has followed it. I want to say that I do not think I ever heard a better discussion of the subject than I have heard this afternoon. I want to emphasize and elaborate a little on one phase of Dr. Moorehead's discussion, namely, that of delinquent children. I believe that 75 per cent of all those children who are classed as delinquent and those which are classed as the bad boys and the bad girls of our public schools are sick children. They are not bad. They are simply sick. And I wish to God that the judges of our juvenile courts would wake up to the fact that they are making more criminals every day by sending these so-called bad boys and girls to our state reformatories. The time has come when every juvenile court should have among its officers a competent surgeon, a man who not only can wield the knife but a man who can make diagnoses of all kinds of ills to which the flesh is heir.

I believe there are a great many of these delinquent boys and girls who have

defective sight. If a boy or girl in a class-room is sitting, we will say 30 or 40 feet from the blackboard, as they sometimes have to do, and the teacher goes to the blackboard and puts an example on it and asks Johnnie to read what is there and he says, "I can't do it," it may be because of his defective eyesight. He does not tell his teacher that he cannot see it, and he is classed as a stupid boy, when he is just as bright as any other child in the room. All he needs is to be taken to an oculist and have proper glasses fitted, and then he becomes a bright child.

The same thing holds true as to defective hearing. A great many times boys and girls have very poor hearing and when they are asked a question they do not understand it, and they are sometimes afraid to ask to have it repeated, and they are therefore put down as stupid; they fail in their work at the end of the year and are allowed to go along year after year in the same grade simply because the child cannot hear well.

There are other children who are suffering from septic conditions of the mouth associated with bad teeth, and as a result are sick. If you and I were suffering just as some of those children are suffering, the ground would be very hot under out feet while getting to a dentist or a physician.

There are others suffering from tonsilar infections, or post-nasal adenoids, or enlarged turbinates, and you all know that if a child has poor breathing space, he or she does not properly oxygenate the blood, and he or she is a dull child. You must have perfect oxygenation of the blood as well as good digestion in order to be healthy, and many of our children are suffering from tonsilar infections and from adenoids and things of that kind which should be removed. Many of them have narrow arches, and those narrow arches should be expanded so that the air passage would be big and wide enough to allow free ingress of the fresh air.

These children are sick and yet they are often classed as bad boys and bad girls and they grow up to feel that every man's hand is against them, and they are not having a fair show, and as result of that they think the world is also against them and they begin to go against the world, and wind up in our jails, in our reform schools and by and by are the criminals of the country, when they are only sick and lacking proper medical, surgical and dental attention. I wish I had time. I would like to talk an hour on this subject. (Applause.)

DR. JOHNSON, of Alabama:

I do not wish to discuss this paper much. I was in hopes that somebody else would bring out the point which I wished to make. I have seen so much trouble caused by impacted wisdom teeth and innocent parts of the mouth suffer as a consequence that I do wish to enter a protest against the extraction of bicuspids, centrals and laterals that are innocent teeth to cure troubles that are obscure and probably caused by impacted molars. I have had a severe case of ear trouble sent to me by a physician to see if I could find anything wrong with the teeth. An upper third molar was found in the lady's mouth, 34 years old, that had not erupted. The only way I found that tooth was by an incision. The removal of it cured the ear trouble. I have seen a man 65 years of age suffering from an infection around an impacted third molar, and the removal of that tooth cured his trouble. But we see men ruthlessly extracting wherever the pain seems to be located so often, that it seems almost criminal to me, to go about extracting teeth just in the region in which the pain seems to be located in the hope that they may find the trouble. How often have any of you seen an exposed nerve in either an up-

per or lower third molar, in which the patient insisted that the pain was in either the lower first molar or second bicuspid, and an attempt at a diagnosis would bring forth most earnest protest from your patient that the pain was in the bicuspid or in the first molar. The point I rose to make is that dentists should not be extracting these teeth either where there is indication that there may be trouble there or not until they have located definitely the trouble, so as not to mutilate a patient's mouth by extracting bicuspids or first molars when the trouble is probably due to an impacted third molar. I invariably search for those things and I believe it is wisdom on the part of all of us to do so.

DR. LODGE, of Cleveland:

Mr. Chairman, ladies and gentlemen: I have been extremely interested in the essay as delivered by Dr. Lyons this afternoon. I want to bring out one point relative to the reflexes that are brought about by impacted third molars. By the aid of the X-ray I have been able to detect pulp stones almost without exception in teeth anterior to the third molar teeth, where said third molar teeth were in violent impaction with the second molars. On extraction of the second molar for the purpose of relieving the impaction, I have confirmed the findings of the X-ray by opening the pulp chambers of the second molar and finding the pulp stone present. Not merely that, but I have also found secondary calcic deposits in the form of excementoses. I would like to ask the essayist, How are these additional sources of irritation brought about, may we not look to these facts, in addition to the impactions themselves, as sources of irritation which may produce profound reflex disturbances?

DR. STEPHAN, Cleveland, Ohio:

Mr. Chairman, members of Section II, and friends: This question, it seems to me, is one of the most living we have to deal with as dental surgeons. I have had the good fortune to co-operate with some of our brightest medical men. It has been my pleasure and my privilege to work with the late Dr. Upson and the late Dr. Cushing. In our investigations of the insane we discovered that melancholia, dementia precox and mania, even of the acute type, were due to these impactions, not especially of this lower third molar but to impactions of any of the teeth. I wish to call attention to one case of mania that came under my care. A young girl was undergoing treatment by the orthodontist. She was about 13 or 14 years of age, as I remember it. In about six months' time she became violently insane. She was the daughter of a physician who took great care of her health. She ran away from home. They did everything for her, all that medicine or surgery could do. They could not control her. She was finally taken to the hospital, and the famous surgeon, Dr. Crile, did all that he could for her physical welfare. However, it was of no avail. In talking over the case we found there were a number of teeth pressing against each other, some impactions, some teeth out of their normal position, and when I rather hesitated at the removal of eight of her teeth, the question came back to me from Dr. Crile something after this fashion, and I give it to you because I think of it as of infinite value: "If any one of these teeth is responsible for the irritation which takes from this girl her mentality, is it not better that we sacrifice all of these teeth and regain her mental balance." Gentlemen, that girl, after the teeth were removed, jumped from a third story window, eluding the vigilance of her physician father. She had been strapped to the bed; she

loosened the straps, no one knows how, and he saw her slide out of that window, and by some miracle—call it so, if you will—she was uninjured, and they found her wandering about on the snowy ground, it being in the winter. Recalling Dr. Moorehead's description of the fixity of mental pain or the mental results of long continued pain, this case came to mind. She has made a progressive recovery. Nothing further was done than the removal of these teeth. It was considered the last hope. This was some six or seven years ago. Today she is in normal health. Wasn't it better to sacrifice every one of those teeth in that case?

There is another case that Dr. Lyons has very kindly consented to report for me that I think is of equal importance.

Referring to the delinquent boy that the doctor has spoken of, I have seen numbers of cases in which the erupting tooth has met an obstacle, and where those erupting teeth have either been removed or the obstacle has been removed and the child has become normal. It was my good fortune with Dr. Upson to examine many of the insane. In one hospital alone, in cases due to impactions, we had, under the wise direction of Dr. O'Brien, at Massillon, Ohio, eight cures. Nothing else was done.

It seems to me that in these cases where we do not have physical pain that the patient recognizes as physical pain. where we may have all of these severe mental symptoms, even to acute mania, is it not our duty, when we find that a patient is low in vitality or has a setback which takes from them the keenness of their mentality, and the physician has gone over their case completely, is it not our duty to make a thoro examination of that case, including radiographs of the whole situation, and determine whether or not there is an irritation somewhere about the mouth which may be responsible for this weakened condition. I think that we have that duty and that we should always do it. I know that I should not permit a friend of mine to be placed in an asylum for the insane or the mentally deficient without first thoroly going over his teeth or having them gone over to determine whether there are—not infections, because infections can be determined—but the pressure of some of the teeth upon obstacles or upon each other, and that those things, if any, are removed. I have seen too many cases cleared up after proper dental treatment. I thank you. (Applause.)

DR. MARSHALL, of California:

I wanted to say something more while I was on my feet and I forgot it. It has not been my privilege to meet with this section but once in thirteen years. Some of you know where I have been. We used to have in this section six to eight to ten and sometimes twelve interested in this subject. Look over this audience now and see what has happened in those few years, and it is very gratifying to me because this subject has been near my heart for many years, and I am glad to see that the dental profession is coming into its own, for this department belongs to them. (Applause.)

DR. ALONZO M. NODINE, New York City:

If you will pardon the personal pronoun, I have made the statement which to ten million people will read that the most important thing, the most important condition in regard to dental conditions affecting a man or woman after they are twenty years old is not decayed teeth, is pyorrhea but impacted teeth. I think I am right from a number of standpoints. By "important" I mean in seriousness of results, the obscurity of the condition, and the influence on the patient's health. And my basis for that statement rests partly upon the work of Dr. Pancoast, of Philadelphia, who has

cured three cases of epilepsy, which had apparently all the symptoms that would pass current for epilepsy. If they were not epilepsy, they were just as good; and he cured them by extracting these impacted teeth, and further we know the experience of Dr. Upson and Dr. Lyons and the gentleman who has just spoken, and I think I am correct in making the claim that the most important dental condition after the age of 20 is impacted teeth. If a person at 20 years of age has not 32 teeth, he should be examined and find out why he has not 32 teeth, and if they are impacted, the operation may be simple or difficult, but nevertheless he should have those teeth removed. I think my mental perspective is correct when I say that the most important thing after the age of 20 affecting dental conditions is impacted teeth.

DR. WILLIAM C. TETER, of Cleveland, Ohio:

I just want to cite three cases out of the large number which have come under my observation. The first was a young lady 17 years old, a very lovely, good girl. In some respects the case resembles the case that Dr. Stephan just gave. If any one thing predominated in her life it was the love for her father. The first thing abnormal noticed in her was the forming of an antipathy for her father. Soon after that she came under the observation of Dr. Henry Upson, the man who has been mentioned so often here, he treating her case and observing her. In a short time she became quite violent. Radiographs were taken, and revealed two unerupted impacted inferior third molars. At the time it was decided to remove these teeth she was in bed screaming at the top of her voice and calling for her father, and when he came near her she would say that he was not her father and would have nothing to do with him. Those teeth were removed and she has made a gradual and complete recovery.

Another case was a man 35 years old, a business man of Cleveland, an architect, a man who, as Dr. Marshall said a while ago in regard to children, just became sick. He consulted the best physicians of our city and there seemed to be a very great difficulty in the diagnosis of his case, but finally radiographs of his mouth were taken, which revealed a superior left cuspid impacted and unerupted. This was removed and the man made a gradual and complete recovery.

Another case was a man 75 years of age. His history was that some twenty years before the time I saw him he had begun to feel something disturbing him, and, of course, he had the natural running down or indisposition. He wasn't really sick but rather indisposed. All of his teeth were extracted but his condition continued about the same. He had worn plates at the time I saw him for fifteen or eighteen years. Up to a few months before he came into the office he could not locate any pain; there was no definite area that caused him trouble, but he had begun to feel in the last few weeks some little disturbance in the lower jaw. When I examined him I saw that the gum was abraded somewhat under the plate and upon making a careful examination I discovered that there was something in the mandible. There was no radiograph taken of this case but it was operated upon, and I found a completely impacted inferior third molar lying entirely, with the exception of a very small part of the enamel of the disto-buccal cusp showing, under the process and the crown of the tooth lower than the roots. His tooth was removed and the man gradually got over the annoyance and depression that he had suffered for these many years. I just cite these cases to show the variety and the different ages at which you may have trouble from these impacted teeth outside of infection.

DR. J. D. PATTERSON, of Kansas City:

Mr. Chairman, Dr. Lyons, ladies and gentlemen. I am very much interested in this subject and I just rise to speak of the most unusual case of impaction that I have had. At a table clinic at the great Chicago clinic I exhibited the remains of the tooth and the instruments used, but I have never described it before an association, so I feel at liberty to do so now.

Of course, most of the impactions which give serious trouble, as has been said by a number of speakers, are of the lower third molar. Very rarely do we have an impacted upper third molar, altho I have had three or four cases of that kind. This was in the second molar, in the superior maxillary upon the right side. A man came to me in December, a farmer, living in Kansas, with a history of the case like this: Trouble for twelve years in the right side of the face, enlargement. Nothing was done, as you know so many times people living out in the country do not have anything done altho they know that something should be done. He did know, however, and his dentist who had attended him knew, that he had never erupted his second molar, and there was a suspicion that the second molar was giving the trouble and that it was encysted and impacted, but nothing was done, and he was during all of the twelve years until he was operated upon last New Years day always in a good deal of discomfort, altho, being very sturdy, he slept well generally, appetite generally good. After the trouble had gone on for five or six years he said that he had trouble with his knees and his feet; his legs below his knees became swollen badly and he was treated for gout. One day he had a rush of pus from his nostril upon the right side, the side of the trouble. The swelling in his knees and feet disappeared within ten days and has never returned. Now, it perhaps is a long shot to say that the infection walled up in the antrum permeated the body and made this condition of the lower limbs, but his physicians which he afterwards consulted in Kansas City, believe that that is true and so does his local doctor. Up to the time he came to Kansas City and had an X-ray taken, nothing was done. The discharge from the nostril continued. The trouble had been going on for the twelfth year when he came to me. His physician, in Kansas City—and, by the way, these physicians in the case were very clever, and I do not combat the physicians at all—they were very clever in this case and generally they have been very clever in cases in which they have consulted me—they had an X-ray taken before he came to me showing the second molar absolutely inverted and the crown penetrating the lower wall of the maxillary sinus. I never knew a second molar in that position, and I do not think the history in our test-books gives any such history, the second molar entirely inverted and the crown penetrating the antrum. When he came to me there was a bad swelling in the face; there was no discharge save the discharge from the antrum thru the nostril. The case was diagnosed by the X-ray man and myself as disease of the antrum from the inverted molar which penetrated the antrum. The X-ray was exceedingly valuable in indicating how the trouble should be removed. The third molar had erupted and the crown was pressed against the first molar. Of course, the eruption of the third molar may have assisted in inverting the position of the second molar. We don't know. I extracted the third molar, and endeavored to make the operation without sacrificing the first molar; I found that impossible and took it out, and we succeeded in getting the remains of the inverted second molar out. The tooth was almost half eaten away in its various aspects and the shell of enamel was all that was

left of the crown. The shell was separated from the rest of the tooth. That came out afterwards. The tooth remains were removed, a large opening made. The antrum was filled, with a tumor rapidly assuming a fibroid character and it was very difficult to remove, but it was removed, the walls thoroly curetted and treated in the usual methods of treating such cases, and in two months he went home cured and perfectly happy. The lower wall of the antrum was entirely gone, and, of course there is an opening there and always will be. He says he don't care; that he is well and happy, and that we saved his life.

There are two or three things worthy of note in this case; the infection that we supposed came from the walled up inflammatory matter in the antrum causing the swelling in his knees and legs; the inverted second molar was quite unusual; and the very rapid recovery. Before he left the healing was perfect. There was no effusion, no pus at all. I felt like speaking of this case along the line of the paper because of the infection which showed itself in the lower limbs and which was entirely relieved, not by the operation but primarily by the bursting of the inflammatory contents of the antrum into the nasal passages and being expelled in that way, relieved infection.

I have been extremely interested in this paper, and especially in what Dr. Moorehead has said about the pain habit, because I have seen that quite a number of times. There is much in it, especially in people who are neurasthenic, and it should be watched very carefully indeed.

DR. ROE, of Philadelphia:

Last week, at the annual meeting of the Pennsylvania State Dental Association, I had the pleasure of presenting a paper entitled: "Surgical Lesions Incident to Oral Sepsis," and during the presentation of that paper I made the statement relative to the so-called impacted or unerupted third molars or other teeth, that I had yet to see a single case in which any irritation, local or distant, was caused by an unerupted or so-called impacted tooth until the cavity in which the tooth was lying had become contaminated or infected by some agent, either bacterial, chemic or other form of irritation, and that the so-called pressure symptoms or irritation was not due to the presence of the teeth primarily but was secondary to the contamination and that contamination was not necessarily due to a direct exposure of the teeth but due to an inner exposure in many cases or in many cases an exposure thru a source that was not easily recognized but could be recognized and demonstrated if certain examinations were made. I have no reason to detract one iota from that statement.

Further, in respect to the essayist, I think he is to be congratulated upon the presentation of the paper and the interest that it has caused in the discussion. But I am here to say that the allusion which he has made in reference to the probabilities of these teeth being the source of malignant diseases—I refer to carcinoma and sarcoma—are over drawn. I have seen a great many cases, operted upon a great many cases of sarcoma and carcinoma of the oral tissues, and I have yet to see a single case where a carcinoma or a sarcoma could be in any proper way ascribed to the presence of an unerupted tooth.

Further, the fact stated in reference to the prevalence of dental cysts is also rather erroneous, in my opinion, pathogenically and surgically, because I have operated on over one hundred and fifty cases of dental cysts, and probably not more than five per cent of the cases had associated with the cyst wall a tooth either fully erupted, partially erupted, displaced, malposed or impacted. The etiology in reference to the formation of

dental cysts over a portion of the follicle of the developing tooth is perfectly correct, but that follicle is the remains of the follicle from which some adjacent tooth had developed and were in normal position and occlusion. I am going to have more to say upon this subject of dental cysts, and I propose preparing a paper which I will offer in the near future.

DR. PATTERSON, of Kansas City:

I would like to add regarding the case I described. I spoke about the antrum being filled with the usual tumor which we find in the maxillary sinus, and I said that it was rapidly taking on a fibroid character. A section of that was taken and examined by a histologist and he pronounced it sarcoma, if it was a sarcoma, came from the impacted tooth, did it or not?

DR. C. J. LYONS:

Mr. Chairman, there are just a few points I wish to clear up. In the first instance, I wish to take exceptions to the remarks of Dr. Moorehead wherein he intimated that I attacked the medical profession. There is positively nothing in my paper that would indicate that, if he listened to it carefully. The two places I have mentioned the medical profession were these: "that until recently the teeth have been disregarded in certain diagnosis;" and the other place was: "unless we do go into this thing in a scientific manner we cannot establish friendly relations with the medical profession." Now, it is not my intention in any way to attack the medical profession They are working hand in hand with the dentists in accomplishing the solution of many of these great problems, and there is no one that is more closely connected with the medical profession in this work than I am myself.

Another point, brought out by Dr. Roe, I believe he misunderstood my paper if he understood I referred to malignant diseases being caused by these teeth. I have mentioned nothing regarding that.

Dr. Stephan, who was a co-worker with Dr. Upson, has kindly given me some data regarding a case, and I am just going to take up a few minutes to read the complete history because it is very interesting and a case wherein the removal of impacted teeth, without any doubt at all, clears up a violent nervous disturbance.

The patient was a teacher 27 years old. When first seen she had been profoundly melancholy for a year. She had had persistent insomnia, many delusions such as that her mind was entirely gone, that she had never been quite sane and that she had committed various dreadful sins. Treatment by tonics and suggestion, by change of scene, and treatment of the uterus proved of no avail. After a year of useless effort, the teeth, which were apparently in perfect normal condition, were examined by skiagraph. An impacted upper third molar tooth was found and removed under anesthesia in February, 1907. The patient had never in her life had a toothache or any indication of disease in the teeth or jaws. She began to sleep well within a week or ten days after the extraction of the tooth. I unfortunately have no letters from her relatives in regard to her condition before the operation. The following letter, however, written about two weeks after the operation, when her condition had improved but little, will give an idea of her sufferings for the preceding two years. Under date of February 19, 1907, her aunt writes: "My niece is very melancholy. If we try to rouse her from that, she moans and groans and takes on over that hobby of hers. She says when she shuts her eyes, she sees those horrible images. She calls them the Evil One, and they are after her. It seems sometimes her mind is trying to grasp something she cannot reach She says her head is

bound. She makes a great effort to break away from the Evil One, as she calls it. As she is not able to, she gets discouraged and settles down into a terrible melancholy. We take her riding and walking, and try every way we can to get her mind from herself. We have to watch her all the time. She threatens so much to destroy herself. She says she don't want to die, but in these desperate spells she may do some dreadful thing. I rub her head on the top and bathe it. She sleeps three and four hours in a night. I have given the sleep capsules two times since I came from the hospital. The outward application seems to relieve somewhat." Under date of March 28, 1907, the aunt writes that her niece "seems quite well. If she could get over that terrible idea, she would be all right. She sleeps well nights, but thru the day she is haunted with that one idea. We try to keep her mind on other things, but for all we can do, at times it will overcome her."

Her return to mental health was steady and was typical in the fact that the delusions persisted longer than the melancholia. In such patients it is practically invariable that the emotional health is recovered first, and that the delusions are got rid of later. In this patient, as the only physical disease was the impacted tooth, the other viscera thruout being healthy, there was an excellent basis of bodily health to build on. Her recovery has been correspondingly complete. Under date of May 8th, 1909, she writes:

"I am very happy to be able to give you a good report of myself. You may be surprised to learn that I have been teaching school since last September. I am somewhat tired now, of course, but during that time I have missed only a few days on account of bronchitis. My school is one of the hardest in the city, I am told. It consists of the fifth and sixth grades, numbering about forty pupils who are mainly backward and undesirable children. They require a vast amount of patience and untiring devotion. My friends at home are quite surprised at my enduring power, my brother having given me, when I undertook the work, two months in which to break down. Fresh air, exercise, careful eating, plenty of sleep, freedom from worry, and a passionate love for my work are the only nerve tonics I am taking.

August 12, 1911, the patient returned with the same trouble, dating back six months. The upper right molar developed an impaction, and was removed, and the trouble cleared up within 24 hours. Dr. Stephan states that last Monday she telephoned him that she is in perfect health, and is now teaching one of the hardest grades in Cleveland, the eighth grade.

I am very much gratified at the discussion which has taken place, and I want to thank each of these men who have so kindly discussed it, and thank you all for your kind attention. (Applause.)

THE RESEARCH DEPARTMENT.

CONDUCTED BY

The Research Institute of the National Dental Association

All Communications for this Department Should be Addressed to the President and (Acting) Managing Director, Weston A. Price, M, S., D. D. S., Research Institute of the National Dental Association, Cleveland, Ohio.

A DEVELOPMENT OF PRACTICAL SUBSTITUTES FOR PLATINUM AND ITS ALLOYS, WITH SPECIAL REFERENCE TO ALLOYS OF TUNGSTEN AND MOLYBDENUM.*

By Frank Alfred Fahrenwald, Cleveland, Ohio.

(A Report of Researches made for the Scientific Foundation and Research Commission of the National Dental Association in Its Metallurgical Department.**)

I. INTRODUCTORY.

Metallurgical research has discovered many an alloy possessing properties not combined in any single metal, and progress still consists chiefly in the investigation and utilization of alloys. In the case of iron, the demands of automobiles, high-speed machines and high-duty engines have led to the production of special iron alloys which will meet any reasonable specifications in that field. In like manner, the bronzes, brasses and other alloys of copper have been brought to remarkable perfection, and for nearly every industrial purpose some alloy has been found more suitable than the pure metal.

Less complete success has attended the attempt to find substitutes for gold, platinum, and the other precious metals. Indeed, it is not likely that a material can be produced which will possess all the properties of any one of them; yet it is reasonable to hope that, for any given

*Condensed from a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

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use, the properties required may be found in some less expensive material. Thus, in incandescent electric lamps, the wire passing thru the thick glass neck of the bulb was, until recently, almost universally made of platinum, for the single reason that no other known material, suitable as a conductor, had the same coefficient of expansion as glass. But a comparatively recent investigation of the iron-nickel series[1] has shown that alloys of those metals may be produced, the coefficient of expansion of which can be accurately controlled between that of iron or nickel and zero. Thus, in that particular industry, a substitute for platinum has been found.

According to statistical reports, not only considerable quantities of gold and iridium, but also more than one-third of the annual supply of platinum, are used (and, in the nature of the case irrevocably lost) by dentists. Platinum is thus employed in several forms. As a thin foil, it serves various purposes for which its high melting point, pliability, chemical resistance, and other properties—including the ease with which it may be soldered—are invaluable. But it is most extensively used in the alloy with iridium, which is more resistant chemically than pure platinum, solders as readily, and possesses, besides, the quality of stiffness, and is not seriously softened by annealing at ordinary soldering temperatures. These advantages dictate its use, in spite of its high cost. The discovery of a substitute in dentistry for platinum and platinum-iridium, especially if it possessed useful properties which they lack, would be eagerly welcomed, and would find wide application in other arts also. The solution of this problem has been undertaken by the Research Foundation of the National Dental Association, for which the work described in this paper was done by the writer.†

The substitute desired must satisfy the following conditions:

1. Its melting point must be high, at least well above 1,200°C.

2. It must not be affected by those chemical compounds formed in its application, nor should it oxidize at a soldering temperature.

3. It must possess sufficient strength to resist stresses tending to change its form while in place, and at the same time be sufficiently pliable to be worked to the desired shape.

4. Its coefficient of expansion must be low, in order that desired dimensions may be easily produced in the finished product. (This factor is important, since the range thru which this material is manipulated is often more than 1,000°C.)

5. It should unite readily with gold, silver and similar metals, and their solders.

6. Its cost of production should be low, as compared with that of platinum.

After the entire list of metals had been considered with respect to these conditions, it was evident that any search for the desired material must be among the alloys, since experience has shown that the physical properties of a metal may be radically changed by the addition of varying amounts of another element, or of several elements, as in the case of steels, brasses and bronzes.

Considerations based upon the periodic law of atomic weights, and the table constructed in accordance therewith by Mendeléeff and Lothar Meyer, led to the conclusion that the field for profitable research was narrowed to the elements chrome, manganese, iron, cobalt, nickel, copper, silver, palladium, gold, molybdenum and tungsten, and their alloys (ru-

[1]C. E. Guillaume: Non-expansive Alloys, The Metallographist, vol. vi, p. 162. 1903. Grenet and Charpy: Dilation of Steels at High Temperatures, vol. vi, p. 238, 1903.

†This work was done in the Department of Mining and Metallurgy, Case School of Applied Science, and the Department of Chemical Engineering, University of Michigan.

thenium, irridium and osmium, likewise theoretically indicated, being ignored because of their costliness and scarcity.)[2]

When two or more metals are brought together in the liquid state, they mix exactly like two ordinary liquids. When the temperature is lowered the solidified mass may contain any one of the four following constituents: Pure components; solid solutions; compounds; and eutectics—or some combination of these.

A comparison of the properties of different alloys containing these constituents has shown that they impart their characteristic properties to the alloy of which they form a part; in fact, the relation between the constitution of an alloy and its mechanical properties is so clearly defined that the possibilities of industrial application may be predicted for a given alloy, if its constituents are definitely known. Conversely, if a certain application is desired, as in the problem under consideration, a definite limit may be placed upon the number and amount of constituents permissible.

Fortunately, the number of constituents is limited to four, as given above. Pure metals impart their own characteristics; solid solutions are, in general, the ductile constituents (if formed of ductile metals or of a preponderance of one ductile metal); compounds and (usually) eutectics are hard and brittle, while the latter, even when present in very small amounts, tend to solidify between the grains of the alloy, thus destroying its ductility.

The problem was to determine what combination, if any, of the elements named, in whatever form, would meet the assumed set of specifications.

Accordingly, each of the 11 elements was combined, in varying proportions, with each of the other 10, giving 55 binary series to be considered with regard to their suitability as practical substitutes for platinum and platinum-iridium alloys.

II. WORK ON ALLOYS MADE BY FUSION.

Behavior under the hammer, or when drawn thru draw plates, and under the influence of acids and alkalies, was sufficient to indicate whether any particular specimen should be discarded at once or made the subject of further investigation.

It was not considered necessary to measure the various melting temperatures encountered, as only a complete fusion, free from all contaminants, was desired. The purity of all components was the highest obtainable, while the purity of the resulting alloys was checked by microscopical and, if necessary, by chemical analysis.

1. Apparatus.

The Gran-Annular electric furnace[3] was used in this set of experiments, and served as no other type of furnace would have done under conditions involving constant use, quick heating and cooling, sensitive control, and low upkeep cost. This is of the granular-carbon resistance type, in which temperatures are limited only by the melting point of the tubes used. With tubes of alundum, it can be safely run up to 1,800°C. This furnace is shown in Figs. 1 and 2, the latter a vertical section, showing also the means adopted for introducing any desired atmosphere into the crucible chamber. This latter device consists of a cylindrical alundum crucible, fitted with a Marquard tube which passes thru the bottom of the furnace and thence to the genera-

[2][Note.—The original thesis contains an interesting discussion of the theoretical considerations above mentioned. It assumes the probability that the physical properties (such as the melting points) as well as the chemical (such as base-forming or acid-forming) properties of the elements bear certain relations to their arrangement according to the periodic law. This discussion has been omitted here to save space.]

[3]Zay Jeffries: Notes on the Gran-Annular Electric Furnace, Metallurgical and Chemical Engineering, vol. xii, p. 154, 1914; also, C. H. Fulton: Trans., vol. xliv, p. 769 (1912).

tor, provided with close-fitting cover, so that a gas may be maintained within it, and surrounding the crucible containing the melt, at a pressure sufficient to cause an outward flow thru all the pores of the chamber walls, thus effectually preventing contamination by the atmosphere of the outer furnace chamber.

When this furnace is run above 1,200°C., the atmosphere within the heating chamber is of the following analysis: O, 0.20 per cent.; N, 68.90; CO_2, 0.70; CO, 30.20 per cent.

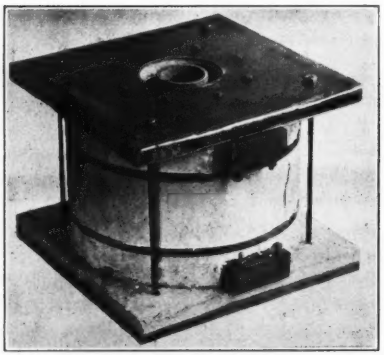


Fig. 1.—The Gran-Annular Electric Furnace.

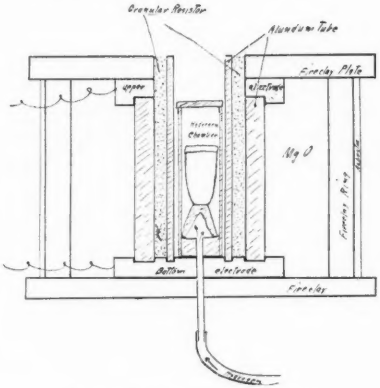


Fig. 2.—Vertical Section of Fig. 1.

TABLE I.—Materials, Etc., Employed in Experiments.

Metal	Crucible Material.	Protective Cover	Inert Atmosphere
Chromium	Carbonaceous material not permissible.		H_2 or N_2.
Molybdenum Tungsten	Magnesia may be used. Alundum questionable.		
Manganese	Magnesia, or a lining of magnesia. Alundum questionable. Silica or carbon must not be present.	$BaCl_2$.	H_2 or N_2.
Iron	Porcelain, magnesia, graphite with magnesia lining, alundum. Carbon or silica should not be in contact with fusion.	$BaCl_2$. Gypsum.	H_2. N_2 forms nitride. CO or CO_2 will carbonize.
Cobalt	Same as for iron, except that porcelain is strongly attacked by oxide formed.	Same as for iron.	H_2 or N_2.
Copper	Charcoal, graphite, porcelain, fireclay, magnesia, silica, alundum.	KCl plus NaCl, borax, KON, charcoal.	H_2, N_2, CO. CO_2, illuminating gas.
Silver	Nickel, iron, fire-clay, graphite, porcelain, alundum.	KCl plus NaCl, borax, KCu, charcoal.	Same as for copper.
Gold	Practically any non-metallic crucible.	None necessary.	None necessary.
Palladium	Magnesia, alundum. Carbonaceous material should not be present.	Glass.	H_2 forms alloy with palladium, altho at lower temperature.

The tests for the general properties of the alloys, such as malleability, ductility, corrodibility, etc., are so simple as to require ordinary laboratory appliances only.

Table I gives a list of crucible materials, protective atmospheres, and covers, which have been found satisfactory in fusing these metals.

2. Results.

Some of the 55 binary series, as, for instance, those high in iron, manganese, or chromium, indicated at once their inability to meet specifications, while others, as those of nickel-palladium, nickel-tungsten, etc., required careful tests, and many degrees of concentration, to determine their comparative properties.

The investigation of these series (with the exception of those high in tungsten or molybdenum, which are not adaptable to fusion methods) is represented by nearly a thousand metals, which are unequally distributed among the different series, the number of fusions necessary in each series depending upon how nearly it approached the standard specifications.

The numerous negative results are not reported here, because they would greatly increase the volume, without correspondingly adding to the value, of this paper. It is sufficient to say that of these 55 series, only those of palladium with gold and silver have proved practically valuable.

The equilibrium diagram of Fig. 3, of the silver-palladium series[4] shows a complete series of solid solutions. Alloys of these, in any proportions, have been found to be very soft, chemically inert, and if chosen of a composition to give a sufficiently high melting point, meet the necessary requirements of a foil to replace platinum, in the field of dentistry. The cost of this material will range from about 1 to 50 per cent. of that of platinum, depending upon the melting point desired.

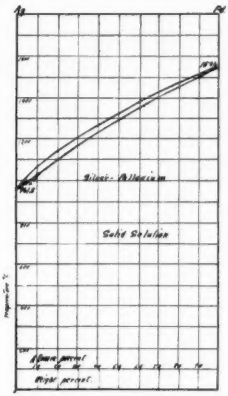


Fig. 3.—Equilibrium Diagram of the Silver-Palladium Series.

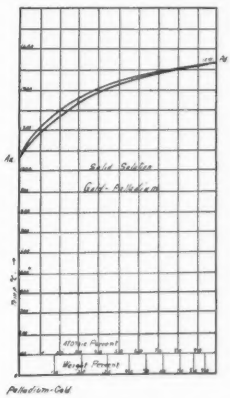


Fig. 4.—Equilibrium Diagram of the Gold-Palladium Series.

The palladium-gold alloys (Fig. 4), however, are superior to those of silver-palladium, as gold is superior to silver. As in the palladium-silver series, the

[4] Reur: Ueber die Legierungen des Palladiums mit Silber, Zeitschrift für Anorganische Chemie, vol. li, p. 315 (1906).

range between liquid and solid is very narrow, resulting in little tendency toward segregation. Fig. 5 shows curves having melting points as ordinates and cost per cubic centimeter, of silver-palladium and gold-palladium alloys, as abscissæ.

Metals are usually price-listed by weight; consequently an erroneous idea is generally prevalent as to the actual relative cost of different available materials, when applied to a given operation. A certain vessel, for instance, will require a definite volume of material, irrespective of its weight, which depends upon its density. Suppose, for example, that the volume of this vessel be 1 c.c. To fill this with platinum will cost, at present quotations, about $30.50; with gold, $12.50; and with palladium, about $22. This is not popular conception of the relative cost of these elements which, when compared by weight, is gold, $20.67; platinum, $48; and palladium, about $60 per ounce.

In connection with this series is a phenomenon for which no explanation is evident; 1 per cent. of palladium darkens gold perceptibly; at from 2 to 3 per cent., the color is a dull light bronze; while at about 10 per cent., no trace of a yellow color can be detected.

In the case of the silver-palladium alloys, a yellow tinge is perceptible thruout the series, which phenomenon is equally hard to explain, considering the pure whiteness of both components.

Altho platinum, in its softer forms, as in foil, may be replaced by the above-described palladium alloys, investigation to this point had produced nothing in the nature of a hard, strong, non-oxidizable, non-corrodible material which would serve as a substitute for the platinum-iridium alloys.

III. TUNGSTEN AND MOLYBDENUM.

This investigation thus far had considered, both singly and in binary combination, the entire list of available metals with the exception of tungsten and molybdenum, the treatment of which, by ordinary fusion methods, was not feasible.

It may be said in advance that any treatment described in this chapter as applying to tungsten will apply likewise to molybdenum. Also, an outline of the

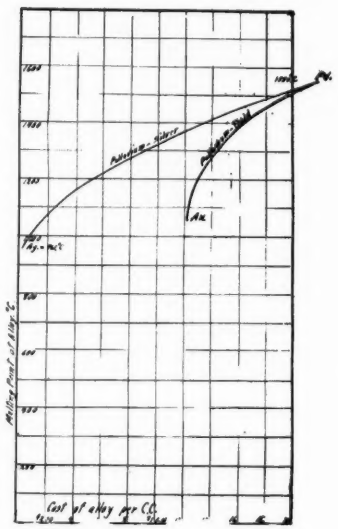


Fig. 5.—Curves Showing Relative Cost of Palladium-Silver and Palladium-Gold Alloys Having Equal Melting Points.

properties of tungsten will include those of molybdenum, which will not be given in detail. Molybdenum is not so hard, not so stiff, and not so chemically resistant as tungsten; but its properties parallel those of tungsten so closely as to permit the omission of their detailed description.

1. Properties of Tungsten and Molybdenum.

Tungsten is popularly best known in its application in the manufacture of incandescent lamps, and more technical-

ly, in the form of its alloys with iron and other metals forming special steels. Its alloys with cobalt, chromium, and similar metals, forming alloys of the "Stellite" type,[5] have also found application.

The remarkable properties of the pure, metallic, ductile tungsten are, however, continually enlarging its field of application. This material is practically insoluble[6] in any of the common acids; its melting point is higher than that of any other metal, its tensile strength exceeds that of steel; it is para-magnetic; it can be drawn to smaller sizes than any other metal, and its specific gravity is 70 per cent, greater than that of lead.

Wrought tungsten has been substituted with success for platinum and platinum-iridium, as contact points in spark coils, voltage regulators; telegraph relays, and for similar purposes. By reason of its greater hardness, higher heat conductivity, and lower vapor pressure, it gives much longer service than platinum. In the automobile industry, for instance, platinum has been in many cases entirely replaced for this purpose by tungsten.

Tungsten gauze is used successfully for filtering acid liquors and where fumes are encountered,[7] while acid proof dishes and tubes are also made of tungsten.[8]

[5]Described by C. L. Sargent: Journal of the American Chemical Society, vol. xxii, p. 783 (1900); and by E. Haynes; Iron Trade Review, vol. li, p 927 (1912).

[6]W. E. Ruder: Solubility of Wrought Tungsten and Molybdenum, Journal of the American Chemical Society, vol. xxxiv, p. 387 (1912).

[7]C. Ehrenfeld: A Study of the Chemical Behavior of Tungsten and Molybdenum and Their Oxides, Journal of the American Chemical Society, vol. xvii, p. 381 (1895).

[8]C. G. Fink: Transactions of American Electrochemical Society, vol. xvii, p. 229 (1910); and the Proceedings of Eighth International Congress of Applied Chemistry, vol. xxvi, p. 503 (1912). Also, I. Langmuir: Transactions of American Electrochemical Society, vol. xx, p. 237 (1911); and W. D. Coolidge: Transactions of the American Institute of Electrical Engineers, vol. xxix, Part ii, p. 961 (1910).

Its tensile strength varies from 300,000 to 650,000 lb. per square inch; its thermal conductivity is more than twice that of platinum; its hardness varies from 4.5 to 8.0 (Mohr's scale), and its thermal coefficient of expansion is only 4.3 by 10^{-6}. That for molybdenum is yet lower, 3-6 by 10^{-6}, while for platinum this value is 8 by 10^{-6}. For many other metals this ranges above 13 to 14 by 10^{-6}.

In short, ductile tungsten meets all but two of the preliminary set of requirements. The exceptions are, that it oxidizes easily at a red heat, and that it does not solder with gold and its alloys, except under strongly reducing conditions. Moreover, it was found that the larger-sized wires of this material were quite brittle, and even those sizes suitable for the purpose specified contained treacherous spots.

But the field of possibilities had, at this stage, narrowed itself to a consideration of this metal, with molybdenum as a second choice. It was therefore necessary to find: First, some means of preventing its oxidation; second, some means of increasing its affinity for gold, silver and their alloys; and third, some method of producing it in more reliable form.

2. Coating with Precious Metals

In earlier work on the gold and palladium series, it was discovered in attempting to alloy tungsten with these metals and while the larger pieces of tungsten were not appreciably dissolved, they were nevertheless removed from the molten bath with a beautiful impervious coating. As either of these furnished the surface qualities which tungsten lacked, the two remaining conditions seemed to be fulfilled. And so they were; but after this bath the tungsten wires were as brittle as glass.

The problem thus arose of applying this coating, of such material, and under such conditions, that the other valuable properties of the tungsten would not be destroyed during the process. The crystallization of the tungsten was obviously due to one of three, or a combination of three causes; improper coating temperature, improper composition of the coating material, or improper time element.

present time. Silver has practically no affinity for tungsten, under ordinary conditions; gold will take up small amounts with difficulty; while palladium will readily dissolve certain amounts of it.

Pure gold, alone, forms a beautiful adherent coating which would serve in ordinary cases; but by adding small amounts of palladium to the coating bath, its melting point is raised, and, at the

TABLE II.—Experiments in Coating Tungsten with Gold, Silver, and Palladium, under Varying Conditions.

Composition			Time	Temperature of Bath							
Per Cent.			Seconds	1,100°C.		1,350°C.		1,500°C.		1,600°C.	
Ag	Au	Pd		Effect on Tungsten	Coating.	Effect on Tungsten	Coating.	Effect on Tungsten	Coating.	Effect on Tungsten	Coating.
100	....	....	10	None.....	Very poor.	None	Very poor.	Very brittle.	Poor.	Very brittle.	Poor.
100	....	....	30	None.....	Very poor.	Quite ..... brittle.	Very poor.	Very brittle.	Poor.	Very brittle.	Poor.
	100	....	10	None.....	Good.	None	Good.	Slightly brittle.	Good.	Very brittle.	Good.
	100	....	30	None.....	Good.	None	Good.	Quite brittle.	Good.	Very brittle.	Good.
		100	10	.....	.....	.....	.....	.....	.....	Very brittle.	Good.
		25	10	.....	.....	Quite ..... brittle	Good.	Very brittle.	Good.	Very brittle.	Good.
		50	10	.....	.....	.....	.....	Very brittle.	Good.	Very brittle.	Good.
	50	50	10	.....	.....	.....	.....	Very brittle.	Good.	Very brittle.	Good.
	75	25	10	.....	.....	.....	.....	Very brittle.	Good.	Very brittle.	Good.
	90	10	10	.....	.....	None	Good.	Very brittle.	Good.	Very brittle.	Good.
	95	5	10	.....	.....	None	Good	Very brittle.	Good.	Very brittle.	.....

These tests were made on drawn wires of 30-mil size, which without the coating, and heated in an atmosphere of hydrogen, crystallized and became brittle at 1,700°C. in from 10 to 20 min.

In order to determine whether brittleness was due to the metal of the bath, or to the factor of time or temperature, tests were made, using varying composition and temperature of bath, and allowing the material to remain in the bath for varying periods.

Typical results, taken from the notes on these experiments, are given in Table II.

As shown in Table II, pure gold gives the best results. Both silver and palladium seem to accelerate crystallization, for some reason not apparent at the same time, a better bond between the tungsten and this protective layer is obtained.

Most of this coating was performed in an open atmosphere. The tungsten was first dipped into a bath of fused sodium carbonate, which operation caused a cleansing and protective shell of this material to cling to the specimen when it was withdrawn. This flux was automatically removed when the tungsten was dropped into the metal bath.

Properties of the Coated Material.—The material produced in this manner pre-

sents the surface properties of pure gold, or its alloys, together with the original internal properties of pure tungsten, a combination which cannot be approached by any other metal or alloy at present available. With few exceptions, the alloys of platinum and iridium are inferior to this coated tungsten.

This is because of the great strength and stiffness of this new material, and due to the fact that it can be soldered, or otherwise manipulated, at high temperatures, without softening or losing this stiffness and elasticity to the slightest degrees.

A comparison of the stiffness of coated

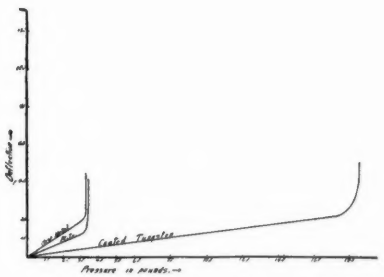


Fig. 6.—Diagram Showing Comparative Stiffness of Coated Tungsten, "Clasp Metal," and Platinum-Iridium Alloy Containing 30 Per Cent. Iridium.

tungsten with that of similar test pieces, one of which is an alloy containing 70 per cent. or Pt, and 30 per cent. of Ir, and the other the so-called "clasp-metal," an alloy of gold, copper and platinum, is shown in Fig. 6. In making these experiments the test wires were supported upon two knife edges 0.5 in. apart, weight being applied upon a third, midway between these two.

The chief remaining objection to this material is its frequent brittleness and unreliability in the larger-sized (above 40 to 50 mils) wires. The quality of this material, as supplied, however, is constantly improving. A discussion of the probable causes of this brittleness, and a suggested method for improvement are given below.

IV. ALLOYS OF TUNGSTEN AND MOLYBDENUM.

1. The Production of Ductile Tungsten and Molybdenum.

The extreme brittleness of tungsten and molybdenum, when produced from the molten state, seems also to be an unavoidable characteristic of their high percentage alloys, when produced in a similar manner. However, in view of the remarkable success which has been attained in the production of these metals in the ductile form, by using methods not involving a preliminary molten condition, and because of the remarkable properties of these metals when so produced, it seemed advisable to determine whether the few undesirable properties could not be properly modified by introducing varying small amounts of other elements, using methods similar to those employed in the production of pure metal.

It was thought that perhaps the additions of small amounts of molybdenum would decrease the extreme brittleness of tungsten, and perhaps result in a material more pliable and ductile in the larger masses, or that the presence of small amounts of the more noble metals would lessen its tendency to oxidize; perhaps even prevent oxidization below relatively high temperatures, and at the same time add such surface qualities that it could be readily brazed or soldered with gold and other precious metals, under ordinary atmospheric conditions.

A description of the manufacture of ductile tungsten, as taken from the literature and patent specifications, gives the operation essentially as follows: The pure tungstic oxide, in certain cases containing a small percentage of ThO_2 (the effect of which will be discussed later), is reduced in an atmosphere of hydrogen. This reduced powder is compressed

into briquets, about 0.5 by 0.5 by 15 cm. in size, which are first sintered at about 1,300°C. and then heated electrically to a temperature near the melting point of the tungsten; after which, by successive swagings at temperatures above a red heat, the material is compacted and welded to a solid metallic mass, and when reduced to about 30 to 40 mils in diameter, it is drawn thru diamond or ruby dies, first hot, and finally cold. All operations involving temperatures above a very dull red are performed in an atmosphere of hydrogen, or nitrogen.

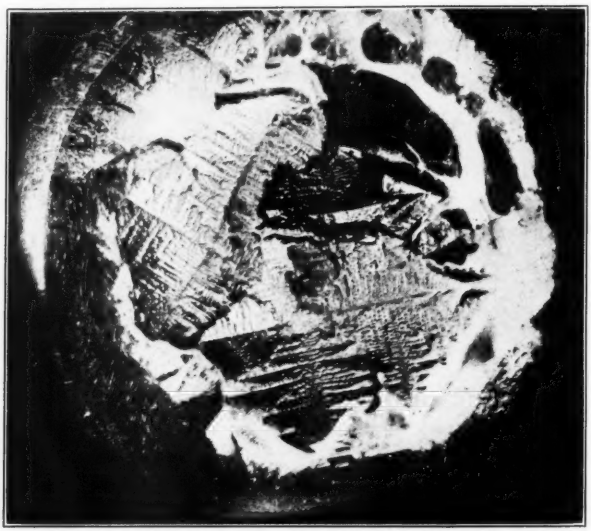


Fig. 7.—Cast Surface of Pure Gold Slowly Cooled. ×6 Diameters.

No reference has been found describing any sort of metallographic control in connection with these various operations, and so far as available information indicates, the above method for the production of ductile tungsten and molybdenum has been developed and employed without assistance from this branch of science. This will, no doubt, account for the difficulty which has apparently been encountered in adapting it to the production of the material of larger sizes in ductile form, and in eliminating the last traces of brittleness in the drawn wires.

No manufacturer of ductile tungsten has been able, as yet, to supply our laboratory with specimens of ductile high-percentage alloys of tungsten. Directly because of this fact, and with confidence in the final success of a method involving proper metallographic control during the various stages of manufacture, experiments were begun to determine the conditions under which such alloys might be produced.

2. The Internal Structure of Metals.[9]

Pure metals, in the solid state, are aggregates of crystals. These do not as a rule possess any regular geometrical shape, but the individual crystalline grains forming this aggregate possess the essential character of all crystals, in having a regular arrangement, or orientation, of matter within their boundaries.

Fig. 7 is a photograph of the cast surface of puregold, which has been slowly and carefully cooled, showing how the interior orientation of molecules has influenced the configuration of the surface

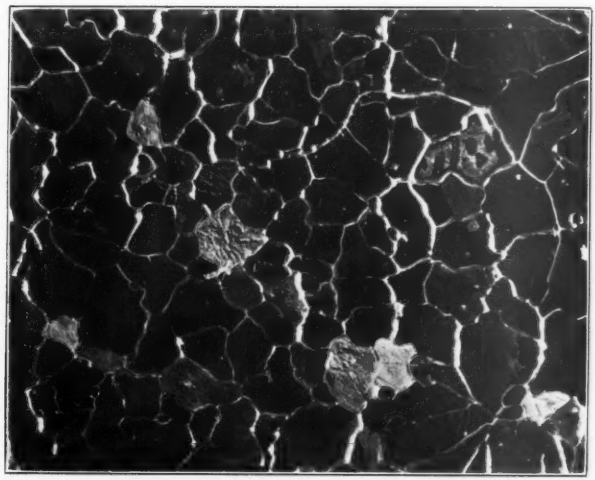


Fig. 8.—Cast Surface of Gold More Quickly Cooled. × 40 Diameters.

[9]Sir J. Alfred Ewing: The Inner Structure of Simple Metals, Journal of the Institute of Metals, viii, p. 4 (1912).

Ewing and Rosenhain: The Crystalline Structure of Metals, Philosophical Transactions, vol. excili, p. 353 (1900); vol. ci, p. 279 (1901).

J. E. Stead: The Crystalline Structure of Iron and Steel, Journal of the Iron and Steel Institute, vol. i, p. 145 (1898).

See also the following for relevant matter:

R. Hooke: Micrographic, London, 1665.

Reaumer: L'Art der convertu le fer forge en acier, Paris, 1722.

Sorby: British Association Report, 1864.

Osmond and Werth: Des Proprietés de l'Acier, Annales des Mines, Series 8, vol. viii, p. 6 (1885).

M. F. Osmond: Sur la Cristallographie du fer, Annales des Mines, Series 9, vol. xvii, p. 110 (1900).

James Thompson: Philosophical Trans., Glasgow (1882).

Behrens: Das Mikroscopische Gefüge der Metalle und Legierungen.

Lehmann: Molekularphysik, vol. i, p. 279.

of each grain. This mass of metal is seen to be made up of two or three crystal groups.

In Fig. 8 the surface is seen to be composed of a larger number of separate grains, irregular both in size and shape. This is a photograph of a more quickly cooled specimen. In this the grains are distinguished not only by these irregular boundaries but by a difference in texture between one grain and another; some are bright, some are dark, while others range intermediately. If the source of light used in making this micrograph be moved, the brightness of the individual grains will change, as shown in Fig. 9; those which appeared bright or dark under the first condition

of lighting will assume a different shade when illuminated from a different angle. This change is due to the fact that the surface exposes a multitude of little facets, or planes, all facing one way in any one grain, but of a different inclination in the different grains. The brightness of each grain depends upon the relative angles of these reflector systems.

Surface conditions indicate that the entire volume of any one grain consists of an assemblage of structural units, which may be likened to the bricks of a wall, all parallel in any one grain but facing differently in the different grains. This has been further verified by a study of cross-sections of metals, and by observation of the fact that certain crystals have been found to act as a three-dimension diffraction grating toward X-rays.

Each grain, then, is a crystal, imperfectly formed, it is true, because it has grown simultaneously from separate nuclei, symmetrical growth being stopped by final contact with neighboring crystals, after which only such parts of the crystal have grown as would serve to fill up the liquid spaces remaining.

Other explanations[10] have been advanced for the formation of crystalline grains, but the assumption that growth proceeds simultaneously from separate nuclei receives the strongest support.

These true crystal grains are found also in metals which have been shaped by cold working. Fig. 10, showing a longitudinal section of swaged tungsten wire, illustrates this rather poorly, but it is given here to show the cold-worked structure of this material. The grains are seen to have been elongated.

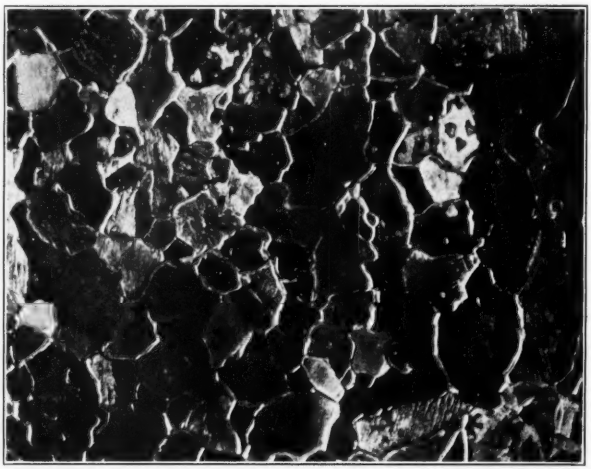


Fig. 9.—Same as Fig. 8, Under Light at a Different Angle.

Many experiments have been performed by many scientists, in attempting to determine what phenomena take place during cold working, by virtue of which the crystal grain would permit such distortion without the destruction of its gen-

[10]C. H. Desch: Solidification of Metals from the Liquid State. Journal of the Institute of Metals, vol. xi, p. 57, (1914). (This contains complete references.)

eral character. The studies of Rosenhain and Ewing,[11] who made a microscopic examination of polished metallic pieces during the actual straining operation, seem most satisfactorily to reveal the internal changes which take place. It was noticed during these tests that a number of fine dark lines appeared across the surface of each grain, being parallel in each but running in different directions in the different grains. This is illustrated in Fig 11, which shows the surface of a distorted bead of cast gold. It was found that these lines or bands were, in reality, small steps produced by shearing at a corresponding number of internal surfaces. It was shown that each crystal grain behaves as does a pack of cards when bent or otherwise distorted, i. e., by the sliding of very thin layers upon each other, so producing the "stepping" at the edges. These observed lines were called slip bands, and by their formation the grains are capable of a certain amount of deformation without breaking up.

To explain how this distortion may probably take place within the mass of the crystal itself which, as a crystal, will not permit of flow, several theories[12] have been advanced, which, when combined and correlated, seem to clear up the matter very satisfactorily, for working purposes at least. It is well known that unequal pressure, when applied to a solid phase alone, lowers its melting point. It should be possible, then, by sufficiently increasing this pressure, to cause the material to melt at ordinary temperatures. Since both liquid and solid phases would at this point be in equilibrium, the molecular activity, or

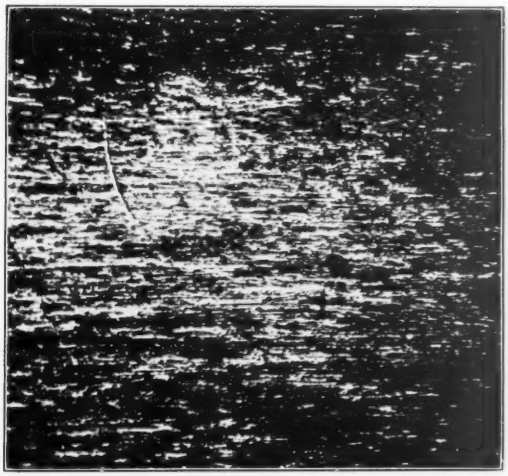


Fig. 10.—Longitudinal Section of Swaged Tungsten Wire. × 770.

[11]Ewing and Rosenhain: Philosophical Transactions, vol. cxcii, p. 355 (1900); and proceedings of the Royal Society, vol. lxv, p. 85 (1899).

[12]G. T. Beilby: The Hard and Soft States in Metals, Journal of the Institute of Metals, vol. vi, p. 5 (1911); see also Proceedings of the Royal Society, vol. lxxix, p. 463 (1907), Proceedings of the Faraday Society, June, 1904, and Philosophical Magazine, vol. viii, p. 258 (1905). Johnson and Adams: High Pressure on the Physical and Chemical Behavior of Solids, American Journal of Science, vol. xxxv, p. 209 (1913).

molecular freedom, of each phase would be the same. By equating values representing these molecular activities, [13] and integrating, with the substitution of proper thermodynamic values, an equation has been evolved by Johnston and Adams, involving the density, heat of fusion, and normal melting temperature, from which may be calculated the pressures necessary to cause the different metals to melt at ordinary temperatures.

Johnston and Adams give the value of P for several metals, as follows: Sn, 2,200; Bi, 3,000; Cd, 3,300; Al, 5,100; Zn, 6,900; Ag, 14,000; Cu, 24,000; Pd, 31,000; Pt, 46,000 atmospheres.

The fact that layers of a solid, many hundreds of molecules in thickness, can really have this mobility of the liquid state conferred upon them by purely mechanical movement was first proved by Beilby,[14] who found that a true skin is

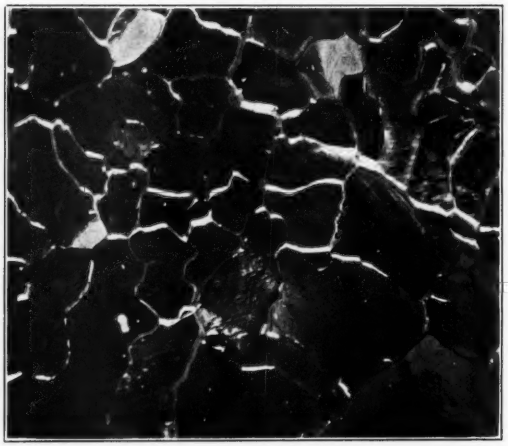


Fig. 11.—Surface of a Distorted Bead of Cast Gold. × 77.

This calculation resolves itself into the following final equation:

$$P = 95.1 \times Q \times D \times \text{Log} \frac{T_1}{T}$$

in which P is the pressure, in atmospheres, necessary to cause fusion; Q is the heat of fusion of the compressed material; D, its density; T_1, its normal melting temperature (Kelvin); and T. the temperature at which it is desired to cause the material to melt.

formed over the surface of a metal during polishing. This skin was found to be distinctly different from the crystalline material beneath it; it was harder, and even when formed on the surface of a crystal, of which the hardness varied in different directions, its hardness was the same in all directions. It was also found to be more readily attacked by solvents.

In polishing, and in any cold-working operation, it is conceivable that those particles which bear the brunt of the

[13] Lewis: A New System of Thermodynamic Chemistry, Zeitschrift für Physiche Chemie, vol. lxi, p. 129 (1907); also, Proceedings of the American Academy of Science, vol. xliii, p. 259 (1907).

[14] G. T. Beilby: Surface Flow in Solids, British Association Report, Glasgow (1901); and The Surface Structure of Solids, Journal of the Society of Chemical Industry, vol. xxii, p. 1166 (1903).

strain will be under a pressure corresponding to that at which they will melt at ordinary temperatures, and so will give way, flowing into areas of lesser pressure where resolidification takes place, leaving the load to be taken up by others in succession. According to this theory, during deformation of a metal, amorphous material is formed at all internal surfaces of shear (as indicated by the formation of slip bands), serving as a cementing material which is both harder and stronger than the crystalline material which it surrounds. This effect is illustrated in the increased tensile strength and stiffness of drawn wires.

Ordinarily this distortion is not carried to the stage at which the crystals are completely converted to the amorphous form, and hence the mass consists of one component in two phases, one of which is in a meta-stable condition. In the case of ordinarily undercooled liquids, the presence of the stable form tends to produce true equilibrium immediately, but in the case of the metals, the sluggishness of the molecules at this low temperature prevents this transformation. However, if the temperature be raised, the kinetic energy of the molecules rises, until, at a certain point, the fragments of crystals which remain are able to impress their orientation upon the molecules of the amorphous substance, and so slowly "absorb" it.

It will be evident that, above this temperature, the kinetic energy of the molecules is so great as to permit their returning at once to the crystalline form when displaced by mechanical distortion. The manipulation of metals below this temperature is the familiar "cold-working operation; above this point, "hot-working." The crystalline state is that of maximum thermal stability and of minimum mechanical stability, while for the amorphous material the reverse is true.

According to the "amorphous cement" theory, it should follow, then, that a metal which has been cold-drawn to that stage which represents the formation of the maximum amount of amorphous material possible will be in the best condition to meet the imposed requirements of elasticity and stiffness.

Intercrystalline Boundaries.—The discussion has thus far included only such changes as may take place within the mass of the crystal itself, without a consideration of the phenomena by virtue of which the separate grains, or crystallites, are held together.

The internal strength of a single crystal, within which the molecules are arranged in a manner involving a minimum of potential energy, and hence of intra-molecular distance, may be ascribed to cohesion due to a mutual attraction of the closely packed molecules. Where two crystals meet, however, it seems improbable that the molecules of the different systems of orientation are close enough to one another to permit a degree of mutual attraction comparable to that existing between molecules of the same crystal. It might be supposed that the intercrystalline boundaries would be surfaces across which cohesion acted less strongly than it does within the mass of the crystal.

These intercrystalline boundaries would then be regarded as planes of weakness, when compared to the strength across any plane within the crystal. But this is not true, for the fracture of metals, in normal condition, always runs across the crystal grain[15] rather than around the boundaries; and it is almost universally conceded, by those familiar with the microstructure of metals, that a fine-grained structure (in which these boundaries are numerous) is superior in reliability and strength to

[15]W. Rosenhain: Deformation and Fracture in Iron and Steel. Journal Iron and Steel Institute, vol. lxx, Part II, p. 212 (1906).

a coarse-grained one—which indicates that the intercrystalline boundaries are planes, not of weakness, but of strength. This has been ascribed by some to an interlocking of the irregular crystallites themselves, and by others to other causes; but a theory[16] which receives strong support supposes the existence of a cementing material[17] between the crystal grains. This theory assumes that when a metal crystallizes from the liquid state, many layers of molecules, lying at the planes where growing crystals meet, do not crystallize, perhaps because of the mutually neutralizing effect of adjacent crystal systems, and so solidify in the vitreous amorphous form. That this view is not untenable is shown in the case of amorphous silica, silicates, and similar substances[18] which occur normally in the crystalline state also. The Phase Rule has, however, developed an excessive tendency to regard the stability which results from the crystalline state as the chief if not the only kind of stability which may exist, under ordinary conditions, in substances normally crystalline.

Such materials as glass, vitreous silica, etc., are harder and usually more brittle, but also much stronger, than the same substances in the crystalline form. Altho these substances are essentially of the nature of liquids, they do not possess the mobility ordinarily associated with that state. Their viscosity at ordinary temperatures is very great, but they do possess the power of flowing to some extent, as shown by the bending of glass tubing under its own weight when placed at an angle for some time; and this property has been shown to exist even in vitreous silica.[19]

Substances of this type solidify to a completely amorphous mass because of the extreme sluggishness of their molecules at and below the freezing temperature, so that cooling may be comparatively slow without resultant formation of crystals.

In the case of metals, however, because of their extreme molten fluidity and long crystallization range below the freezing point, it has been found impossible to cool them from the molten state so quickly as to produce a completely amorphous solid. This has made it difficult to obtain direct experimental verification of the "amorphous cement" theory, as advanced in explanation of the strength of intercrystalline boundaries and the increased strength and hardness of cold-worked metals. It has been admittedly impossible, with the means at present available, to answer this question by any attempt to produce completely amorphous metals from the molten or crystalline states. However, by adopting a difficult method of attack, comparable to that employed in synthetic processes, the writer has, in a manner, overcome this difficulty—sufficiently so, at least to point out the remarkable way in which the physical properties of a simple metal may vary with its internal structure.

New Experimental Evidence in Support of the "Amorphous Cement" Theory (the Influence of Phase upon the Physical Properties of Gold.

According to the "amorphous cement" theory, then, the strength of the intercrystalline boundaries in metals is due to the presence of material which has not crystallized, and the increased strength of coldworked metals is due to

[16]G. D. Bengough: A Study of the Properties of Alloys at High Temperatures, Journal Institute of Metals, vol. vii, p. 9 (1912), and Discussion by Rosenhain, p. 176; also J. A. Sears: On the Longitudinal Impact of Metal Bars with Rounded Ends, Transactions Cambridge Philosophical Society, vol. xxi, p. 105 (1908).

[17]Rosenhain and Ewen: Intercrystalline Cohesion in Metals, Journal of the Institute of Metals, vol. viii, p. 194 (1912) and vol. x. 119 (1913).

[18]Tamman: Krystallisiren und Schmelzen.

[19]Kay: Thermal Hysteresis of Fused Silica, Philosophical Magazine, Series 6, vol. xx, p. 718 (October, 1910).

the formation of the amorphous phase during manipulation.

If the assumption that greater strength in metals is due to amorphous material present be sound, then a metallic mass known to contain the amorphous phase should possess properties differing from those of the metal when in the crystalline state.

The scheme adopted for testing this assumption involved the preparation of a series of gold briquets, made up of gold particles representing a different degree of subdivision for each briquet of the series, from coarsely crystalline to as near molecular proportions as could be obtained. This series consisted of four groups, each comprising several specimens for the different tests. No. 1 was made of pure cast gold, and represented a purely crystalline condition. No. 2 was made of fine gold filings, which represented a certain amount of amorphous material produced by extreme cold-working conditions. No. 3 was prepared from the precipitate formed by ferrous sulphate, and represented a very fine state of division. No. 4 represented the ultimate limit of practicable subdivision. These briquets were prepared from a mud of colloidal gold, produced as follows: A deep red colloidal gold solution was prepared by reduction with 0.5 per cent. solution of hydroxylamine hydrochloride. This solution was carefully dialyzed to remove alkali salts, then evaporated to a "mud," and further dried on a water bath. It was found difficult to prepare a red solution containing more than 0.05 per cent. of gold, and even this, upon concentration, became greenish in color and resulted finally in a grayish-green sludge.

The size of gold particle, as determined for a red-gold colloidal solution, is of about 10 to 20 microns. This size was no doubt increased, as indicated by a change in color, during evaporation. About 7 liters of this dilute solution was reduced for each briquet.

The apparatus used for briqueting this material was the same as that used for tungsten and molybdenum, and is described below.

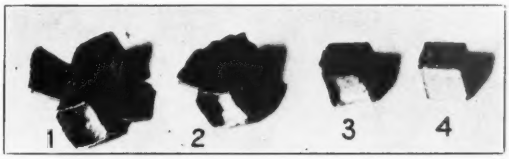


Fig. 12.—Flow Under Pressure of Gold Briquets of Different Structure.

The behavior of each of these series is strikingly shown in the photographs, Figs. 12 and 13. The different extent to which each would flow thru the small openings between the different parts of the briquet press is remarkable. Nos. 1, 2 and 3 were made under the same pressure, 9,700 kg. per square centimeter (about 135,000 lb. per square inch), and contain the same weight of gold. In the case of No. 4, the utmost pressure available, 19,300 kg. per square centimeter (about 265,000 lb. per square inch) did not cause any indication of flow. A similar striking difference is shown in the case of the Brinell hardness number of each of these series, using the large ball and a pressure of 500 kg. No. 1 was too soft to bear this weight, so the hardness number was taken from a bar of rolled and annealed gold and found to be 23.80. The hardness number for No. 2 was

38.10; for No. 3, 53.40; and for No. 4, 94.70. These depressions are shown comparatively in Fig. 13.

Other striking phenomena were noted in connection with these series, but their behavior under pressure will serve to point out the fact that much remains to be discovered regarding the physical properties of simple metals; as well as what may be expected should this knowledge lead to a control of phase.

The important feature of these results, however, is the apparent support they give to the amorphous cement theory of Beilby, Rosenhain, and others, above. Since these results have shown that characteristics of an amorphous metal

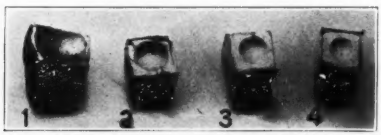


Fig. 13.—Comparative Hardness of Briquets in Fig. 12.

are great hardness and resistance to deformation, nothing could more nearly explain the increased strength of the cold-worked metals than a theory assuming the formation of amorphous material during manipulation.

3. Practical Deductions.

With the application of these crystallographic considerations, the probable cause for the difficulties encountered in the production of ductile tungsten, and to a greater extent, of ductile tungsten alloys, seemed apparent. Careful microscopical examination of many specimens of drawn wire submitted to this laboratory revealed in all cases that brittleness is accompanied by a difference in crystal structure. Fig. 10, already described, showed a longitudinal section of drawn tungsten wire, which was very tough and flexible. Fig. 14, a longitudinal section of a similar wire, which was exceedingly brittle, clearly shows the discontinuity of the drawn, fibre-like structure.

In discussing the internal structure of metals it was pointed out that a sufficiently high temperature would permit the complete crystallization of amorphous metal. The larger crystals of this mass may impress their orientation upon the molecules of smaller crystals, thus causing crystal growth; and mechanical distortion, above a certain temperature, will not greatly reduce this grain size.

In devising a method for producing tungsten and its alloys in a non-brittle form, these points were regarded as fundamental. The brittleness of the examined specimens of drawn tungsten was regarded as due to an insufficient breaking up of its crystalline structure. Hence, in producing this material, or its alloys, in ductile form, it would be necessary to eliminate excessive crystalline material; and in order to accomplish this, the following means suggested themselves, based upon deductions drawn from earlier conclusions regarding the behavior of worked metals in general.

1. In order to produce a practical minimum of crystal size in the starting ingot, the treating temperature must be as low as possible.

2. In order to decrease the amount of crystalline material, cold-working conditions must prevail.

3. In order to introduce sufficient distortion, with its accompanying formation of the maximum amount of amorphous material, resulting in greater ductility in the larger sized wires, drawing should be commenced at an earlier stage in the reduction of the briquet, because this operation is much more effective in breaking up a crystalline structure than is swaging.

4. For obvious reasons, the above operation should be controlled by microscopical examination. Internal structure, not temperature, is the treating criterion.

That these premises are fundamentally sound is shown by the following results of experimental work.

V. EXPERIMENTS.

The experimental work, which involved the application of the above considerations, and the results of which are outlined in this paper, included investigations of the following series: pure tungsten, tungsten containing 0.75 per cent. ThO_2, pure molybdenum, tungsten-gold, tungsten-palladium, tungsten-molybdenum.

The method adopted comprised the compression of amorphous powder to briquet form; the heat treatment of the compressed material; and the forging of the resulting ingot.

The tungsten and molybdenum used in these experiments were obtained thru the courtesy of the Cleveland branch of the General Electric Co., and were the chemically pure material used for the production of drawn wires.

The tungsten was of two batches, one containing 0.75 per cent. of ThO_2 which is the material largely used for lamp filaments, while the other was tungsten in which no trace of impurities could be detected. The gold and palladium were purified in this laboratory by several reprecipitations. The preparation of the amorphous material, from which briquets were made, will be described in connection with the different series.

1. Compressing Powder to Briquet Form.

The mold used in producing the raw briquet is shown in Fig. 15. This consists of two halves of hardened tool steel, held together by strong bolts. Into each half is milled a polished V-shaped groove, so that when the two parts are bolted together a square chamber is produced. Into one end of this chamber the plug D is inserted, and after filling the chamber with the material to be compressed, the plunger C, is forced into place. This plunger is steel containing tungsten, 16.5; chromium, 2; and carbon, 0.6 per cent., which, after heat treatment, has been tested under pressure exceeding 300,000 lb. per square inch. The face of the plunger was highly polished so that one surface of the raw briquet was available for micro-examination.

The design shown in Fig. 16 was a failure, since the adhesion between the briquet and the semi-cylindrical surface

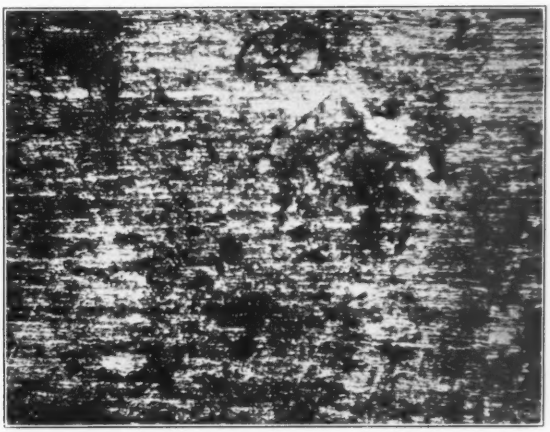


Fig. 14.—Longitudinal Section of Brittle Tungsten Wire. × 743.

of the mold was greater than the cohesion across the section within the briquet itself, causing it to split while being removed.

Compression was obtained in a Brinell

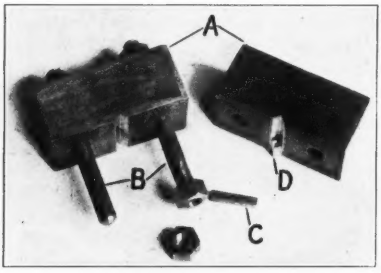


Fig. 15.—Briquet Mold.

hardness-testing machine, the ball, with its socket, being replaced by a special head. The press A was placed upon the adjustable table as shown in Fig. 17, so that the plunger came axially under the piston of the machine. This machine gave very sensitive and accurate control up to a total load of 4,000 kg. Various total loads, when exerted upon the piston

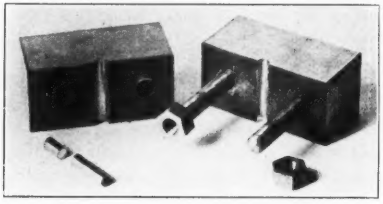


Fig. 16.—Unsatisfactory Briquet Mold.

of 0.207024 sq. cm. in cross-section, are given in comparative values as follows:

Total Pressure,	Kilograms Per Square Centimeter	Atmospheres	Pounds per Square Inch
500	2,412.7	2,335.5	33,561
1,000	4,825.5	4,671.0	67,122
2,000	9,651.0	9,342.0	134,244
3,000	14,476.5	14,013.0	201,366
3,750	18,095.5	17,516.0	251,707
4,000	19,302.0	18,684.0	268,488

2. Heat Treatment of the Compressed Material.

Quartz-Tube Furnace.—Fig. 18 shows a quartz-tube furnace which was used for the reduction of tungsten and molybdenum, and other oxides and salts; also for

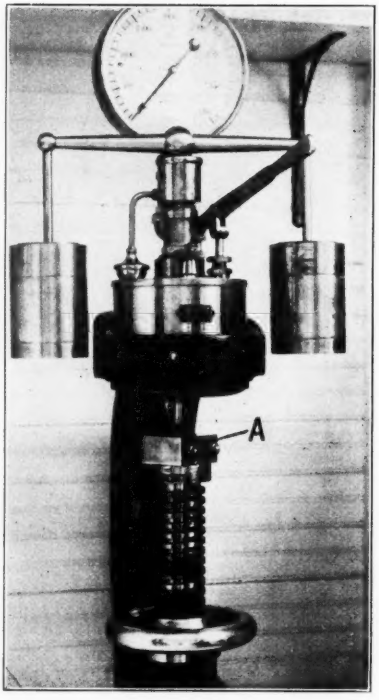


Fig. 17.—Machine for Compression of Briquets.

various purposes where heating in controlled atmosphere was desired but where very high temperatures were not necessary. In this, temperatures up to 1,225°C. are easily and quickly reached. The fused quartz tube, A, has a glass window at one end, and at the feed end the plug, B, which can be removed for the insertion of the boat containing the material to be treated. Hydrogen, or other gas, enters thru tube

C and escapes thru the bubbler D. A Meker blast lamp, E, was used for heating. The method of sighting with optical pyrometer F is also shown.

Gran-Annular Electric Furnace.—For temperatures up to 1,800°C. this furnace far surpasses any other type which the writer has used in experimental work of this kind.

Figs. 1 and 2 showed this furnace in

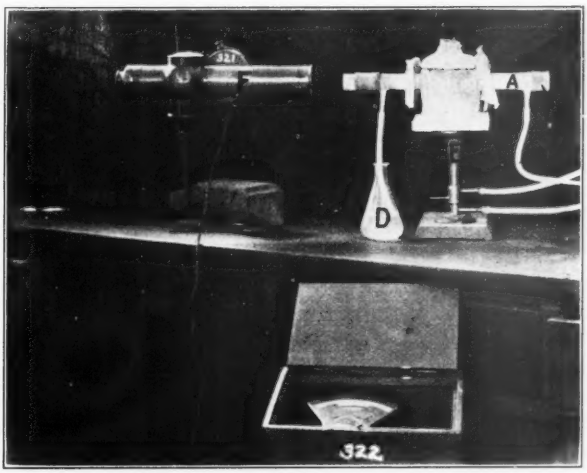


Fig. 18.—Quartz-Tube Furnace.

detail Fig. 19 shows a setup of the furnace, A, in series with cast-grid rheostat, ammeter, and switchboard. An optical pyrometer, B, points directly into the heating chamber of the furnace.

Electrical Resistance Furnace (Resistance of Charge).—The above furnace equipment, however, did not provide for the treatment of tungsten and molybdenum briquets, or those containing high percentages of these metals. Moreover, it provided no means for forging these ingots. This operation had to be carried out at high temperatures and in an inert atmosphere. Fig. 20 gives a vertical section of a furnace so designed as to furnish temperatures ranging from that of the furnace room up to, and above 3,000°C., depending upon the material of the briquet, and also to serve as a forge for working the material into a solid mass while at a high temperature. This consists essentially of two adjustable electrode bars, A and B, fitted with fused tungsten contact surfaces, C, between which the briquet, D, is placed. Current is passed thru the briquet which, by its own resistance and that between the contact surfaces, may be heated to any temperature up to its melting point. An inclosed heating chamber, E, is formed by dropping the sliding cup, F, into a close-fitting recess made for it at the base. Gas is passed thru the tube, G, into this chamber, from which it escapes thru the outlet shown. This opening serves also as a peep hole for the optical pyrometer.

In operating, the bar, A, with its electrode and housing, F, is raised thru its guides, H and I. The briquet, D, is then placed in position on the lower elec-

trode, C, after which the upper electrode is lowered to contact. The inverted cup, F, is then lowered into place, forming the chamber, E, thru which is passed an inert gas, swiftly at first, to expel the air, and then slowly, as indicated by a bubbler in the purification train. To avoid the fracturing of very fragile briquets, and to prevent a resulting short circuit, the coil spring, J, with adjustable collar, is placed so as to support the excess weight of bar and cable.

Fig. 21 is a photograph of this furnace with its door removed so as to show the different parts in place for heating. Fig. 22 shows the complete setup: A, being the furnace; B, a hydrogen generator; and C, an optical pyrometer in position for reading the briquet temperature, which is indicated on the scale contained in the case D.

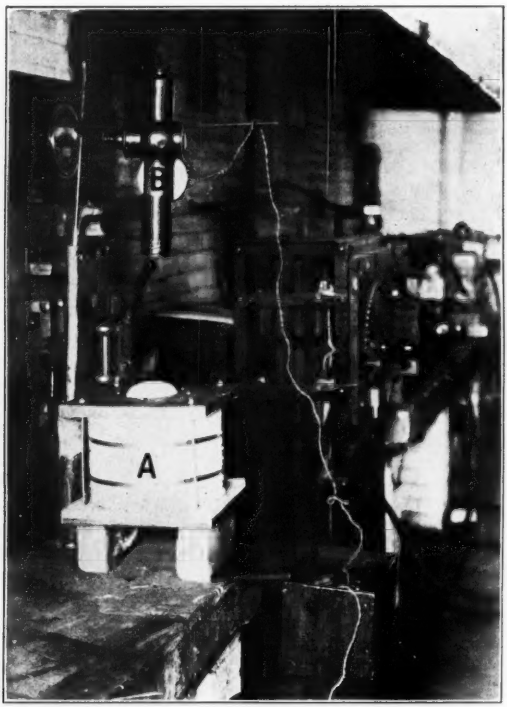


Fig. 19.—Gran-Annular Electric Furnace with Connected Apparatus.

Forging.

This furnace was designed to be used as a forge, and at the same time to maintain the temperature at which the material of the briquets could be shaped. During this operation the lower bar was firmly supported, while blows were struck with a hammer upon the upper electrode. The increasing of the cross-section and the welding of the material would reduce the resistance considerably,

resulting in a lowering of the temperature, unless an increased current were used; but, by pyrometric observation and current regulation during the forging operation, the temperature could be kept fairly constant. The peep hole permitted direct observation of the briquet at all times.

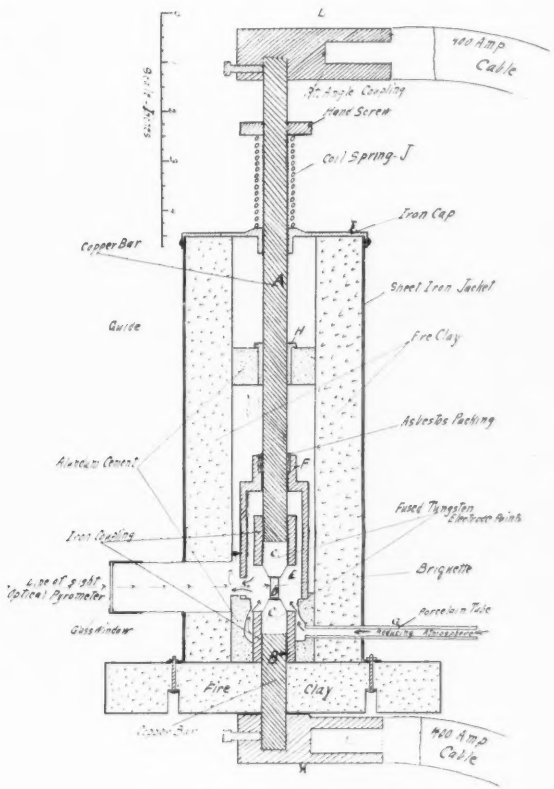


Fig. 20.—Electrical Resistance Furnace.

Temperature Measurement.—The conditions under which high temperatures were to be maintained did not permit the consideration of any thermometer or thermocouple method of pyrometry. The practical methods available were those based on the various radiation formulæ, or upon optical observation. A review of this branch of pyrometry revealed an abundance of literature,[20] upon the governing principles of these methods, and their practical application. Of the various types of instrument of this class available, that one was chosen as most practical under the prescribed conditions which involves a direct telescopic com-

[20] G. K. Burgess: Measurement of High Temperatures (A complete treatise and bibliography). See also C. E. Mendenhall and Forsythe, Physical Review, vol. iv, p. 163 (1896-7).

parison of the luminous radiation of the hot body with that of a standard source. There are two makes of this type; one, the Holborn-Kurlbaum,[21] and another, of almost identical construction, the newer type of Morse Thermogage.[22] The working principle is the same in both. A current is passed thru the filament of a lamp, which first becomes red and then, with increasing current, successively orange, yellow and white. By interposing this filament between the eye and the

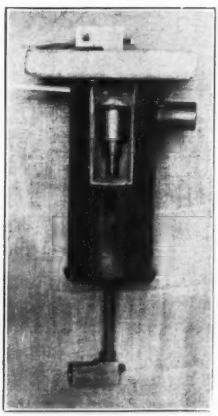


Fig. 21.—Electrical Resistance Furnace.

hot body to be measured, the current thru the lamp may be adjusted until the middle of the filament is of the same color and brightness as the object. At this point the part of the filament used for comparison will disappear against the bright background. The current thru the lamp, interpreted in terms of temperature, gives the temperature of the hot body. An absolute match of both color and brightness cannot be made, unless monochromatic light is used, because of the fact that the lamp filament and the viewed body do not radiate similarly. This comparison is facilitated by a suitable arrangement of lenses and lamp, as in the instrument of Morse, which was the one used in this work. This is shown diagrammatically in Fig. 23. A low-voltage incandescent lamp, L, with M-shaped filament is mounted in the focal plane of the objective, O, and the eyepiece, E, of a telescope is provided with means of focusing. The lamp circuit is shown connected thru a battery, a rheostat, and a milliammeter. Fig. 24 shows this instrument with positions of the rheostat, A, and lamp, B. Fig. 25 shows a portable case containing battery, milliammeter, and pyrometer.

Temperatures were determined by focusing the instrument upon the briquet so as to bring its image into the plane of the lamp filament, then adjusting the current, by means of the rheostat, until the tip of the filament disappeared against the image of the briquet, when the temperature was read directly from the milliammeter scale (previously calibrated by checking current readings against known temperatures).

Below 1,200°C. readings were made directly, while above this temperature a neutral-colored absorbing "Rauch" glass (R, Fig. 23) was interposed between the lamp and the objective, in order to prevent the blinding effect of too great brightness, and also, to avoid overheating the standard filament A new calibration was necessary when this absorbing screen was used For temperatures above 1,900°C. it was found necessary to cut down the amount of light entering the pyrometer by means of a diaphragm, with the use of which temperatures up to that of the arc could be read.

The instrument was carefully standardized in all three ranges. The first, in which no absorbing glass was used, was carefully checked against an accurate thermocouple. The second range, using an absorbing light screen, was checked

[21]Made by Siemens & Halske Aktiengeschellschaft, 94 Markgrafenstrasse, Berlin.

[22]Made by Morse Thermogage Co., Trumansburg, N. Y.

up to 1,375°C. against a thermocouple, and at higher temperatures by the freezing points of palladium and platinum. The Gran-annular electric furnace was used in this standardizing work up to, and including, the melting temperature of platinum, and for this purpose approximated very closely the desired black-body conditions. These standardizations gave current-temperature curves up to nearly 1,800°C., which could be continued by interpolation, with a fair degree of accuracy, up to 2,000°C.

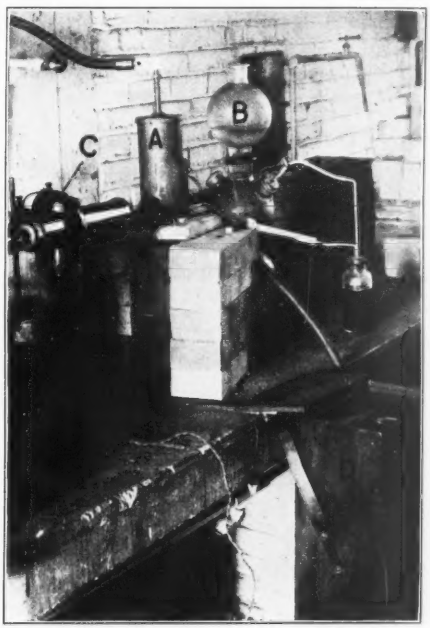


Fig. 22.—Electrical Resistance Furnace, with Connecting Apparatus.

A third curve was formed by the melting points of platinum, iridium (2,200°C.) molybdenum (2,500°C.) and tungsten (3,000°C.). These latter points were obtained by sighting on electrically heated strips of the metals formed into narrow wedges, as recommended by Mendenhall[22] which produces a deep cavity giving very near block-body conditions. The tests on tungsten and molybdenum were made by grinding very thin a portion of a piece of wire, which, on account of the resulting small cross-section, heated very readily. These tungsten and molybdenum strips were arranged as lamp filaments in a glass tube, in vacuo. Readings were also made on fusing briquets of these metals, when heated, under operating conditions in the above-described resistance furnace.

A final reading was made on the positive crater of the arc, accepting for this a temperature of 3,600°C. It has been shown that an absolute match of both color and brightness cannot be made, un-

[22]Burgess and Le Chatelier: Measurement of High Temperatures, 3d edition, p. 334 (1912).

less monochromatic light is used, or unless the lamp filament and object radiate similarly, which is seldom the case. All observations were therefore, taken thru

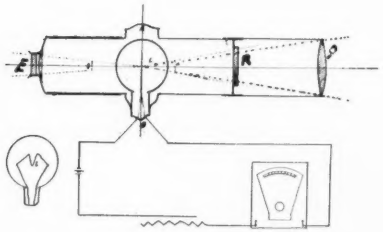


Fig. 23.—Diagram of Morse Thermogage.

red screens, which, with a radiation characteristic of about 2,000°C., gave a very narrow band with maximum of transmission at $\lambda=0.659\mu$.

In all readings care was taken to main-

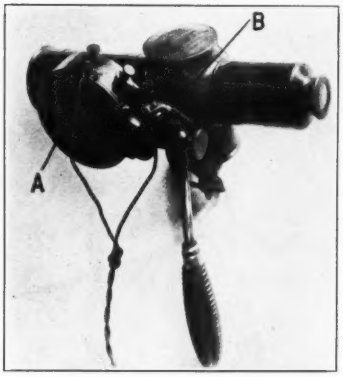


Fig. 24.—Morse Thermogage, with Rheostat and Lamp.

tain axial symmetry and constant distance from the hot body to the objective, thus insuring a sufficiently large background, and also constant angles at ɔo and ζ.

The accuracy of this method of pyrometry has been fully proved and is such that between 1,000°C. and 2,000°C. the error of reading should not exceed 10°C. Above this range the error was found to be somewhat greater, but not so great as to interfere in any way with a duplication of desired conditions.

Metallography.

Grinding and Polishing.—After heat treatment the ingots were made ready for microscopical examination. The

Fig. 25.—Portable Case, Containing Battery, Pyrometer, Etc.

preparation of specimens of this small size (about 0.5 by 0.5 by 1.0) cm. was rather a delicate operation, but the final surfaces secured were all that could be desired. Excellent apparatus was available for this purpose, while the three grades of alundum, F, XF, and 65F, were found to be sufficient for polishing all samples. Care was taken during these operations not to introduce surface conditions which would mask important internal phenomena.

Etching.—For pure tungsten and molybdenum or their high-percentage al-

loys, the most satisfactory etching reagent was found to be concentrated hydrogen peroxide. It is necessary, however, to have this boiling while in contact with the specimen, otherwise it is quite inert. For the alloys containing a precious metal also, either hydrogen peroxide or aqua regia was used, depending upon whether the tungsten and molybdenum, or the precious metal was to be attacked.

Microscopy.—For microscopical examination, there was available, from both Carl Zeiss and E. Leitz, a very complete equipment, the detailed description of which is not deemed necessary.

Results.

In order to test the soundness of the premises upon which the experimental work was based, it was necessary that experiments should first be directed toward the production of workable masses of pure tungsten and molybdenum themselves, for, should this not be possible, it would be useless to extend the work to their alloys; and, conversely, should these pure metals yield to such systematic treatment, as based upon conclusions drawn from earlier study of the probable theoretical conditions involved, then the application of similar methods should meet with success in the treatment of their alloys.

It must be pointed out here that no treatment would overcome defects in these alloys due to chemical interactions, but that if, for instance, brittleness, as in the case of tungsten and molybdenum, is due to a purely physical condition, then a method based upon the above considerations should meet with success.

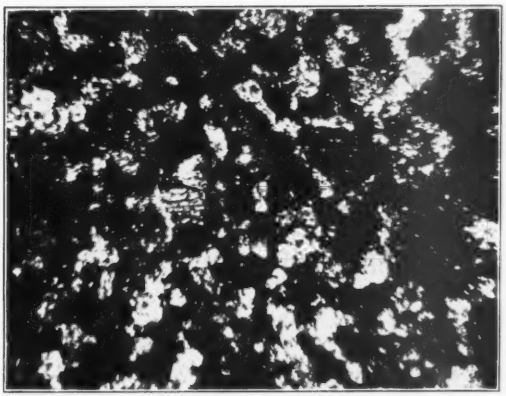


Fig. 26.—Result of Long, Relatively Low Heating.

There are two fundamental critical points to be determined: First, the proper ingot-forming temperature; and second, the lowest possible temperature at which this ingot will yield to mechanical working. This latter point must obviously be below the hot-working range.

With the above considerations in mind, and in accordance with the principles laid down in the preceding pages, the experimental work has been carried out, with results as shown briefly under the following separate heads: (1) Pure tungsten; (2) pure tungsten plus 0.75 per cent. ThO_2; (3) pure molybdenum; (4) tungs-

ten-gold series; (5) tungsten-palladium series; (6) tungsten-molybdenum series.

Pure Tungsten.—The pure tungsten briquets of this series were made under a pressure of 14,500 kg. per square centimeter (about 200,000 lb. per square inch). The specific gravity of the resulting briquet was 13, taken as an average of nine specimens. This was determined from micrometer measurements of volume, and weight of the specimen, and represents about 30 per cent. of void in the briquet.

From numerous results, the following are taken as typical of the changes which take place upon treating the amorphous briquets at various temperatures:

TABLE III.—Results of Heat Treatment of Briquets.

Number of Specimen	Treating Temperatures	Time of Heating		Remarks.
	Deg. C.	Hr.	Min.	
5	500	1	0	Fairly coherent. Partly sintered. Could not be polished.
6	600	1	0	Harder and stronger than No. 5. Could be poorly polished.
8	800	1	0	Hard and metallic. Filed with difficulty. Polished readily.
10	1000	1	0	Very hard and metallic. Polished to beautiful surface.
12	1200	1	0	Appeared microscopically as solid metal. Very hard and brittle
14	1400	1	0	As No. 12. No crystal formation.
16	1600	1	0	An apparent internal change, which could not, however, be called crystalline.
18	1800	1	0	Showed changes indicating crystal formation, but with no definite outlines. (Gran-Annular furnace.)
22	2200	0	10	Appeared about as No. 18. (Briquet resistance furnace.)
26	2600	0	10	Very finely crystalline with many intercrystalline boundaries not clearly defined—indicating presence of amorphous material.
27	2700	0	5	More coarsely crystalline than No. 26 with crystals in center larger than at sides.
28	2800	0	1	About as coarsely crystalline at surface as No. 28, but area in center indicated a complete liquid fusion.

The extent and type of crystallization were found upon the time-temperature factor. Prolonged heating at relatively low temperatures gave fewer and larger crystals, and crystals of different sizes (Fig. 26), while a flushing at higher temperatures (specimens No. 26) gave a very fine and uniform crystalline structure (Fig. 27), which was much to be preferred. In specimen No. 28 (Figs. 28 and 29), the heat of radiation from the sides of the briquet was so great that while the surface-temperature reading was only 2,800°C., the molten interior indicated a temperature above the melting point of tungsten (3,000°C.) at the center. Photomicrographs, Figs. 30 to 32, show the transition from the compressed powder to a solid, metallic, apparently non-crystalline mass, and finally to a solid, crystalline ingot.

The next step was to determine which of these stages of crystallization gave the best forging conditions. This was done by treating a series of each of these numbers at varying temperatures. It was found that, within certain limits, the lower the sintering temperature, the higher was the initial temperature necessary for forging.

No. 5 could be forged at about 2,400°C.; No. 10 at about 2,200°C.; No. 18 at about 2,000°C.; No. 22, at about 1,700°C; No. 26, at 1,275°C.; No. 27, at 1,350°C.; No. 28, at 1,375°C. These figures, of course, represent the initial welding temperature of the more or less powdery mass, the necessary temperature falling at once when this welding had begun; they give no definite information other than indicating the necessity for at least partial crystallization in the treated ingot. Below these high temperatures the specimens were brittle in the first stages of forging, and if these temperatures were maintained after forging began, there re-

sulted a marked crystal growth, instead of the desired reduction.

These series were represented by 92 forgings, or attempted forgings, and the results gave a curve with a minimum forging temperature corresponding to a certain crystal size. This is represented approximately by No. 26 (micrograph Fig. 27). A higher temperature for a shorter time would give nearly the same conditions, or a lower temperature for a longer period. It is thus seen that it would be useless to prescribe a definite treating temperature, or even one for forging, because the temperatures recorded were observed under rather restricted conditions, and in apparatus giving the worst possible conditions as to

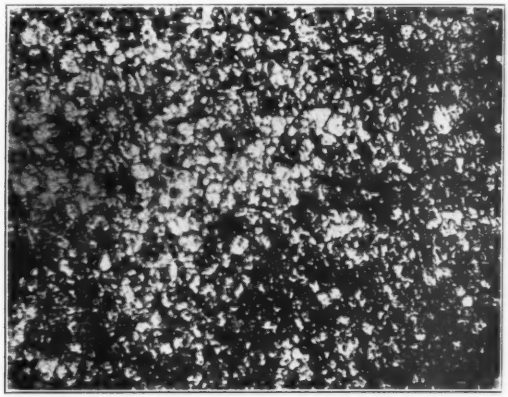


Fig. 27.—Result of Quick High Heating.

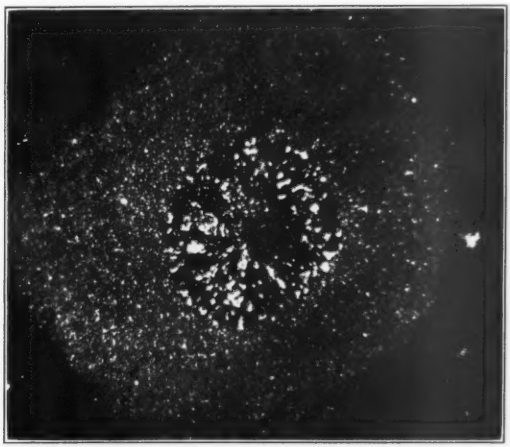


Fig. 28.—Molten Interior, Specimen 28.

radiation, uniform heating, etc., due to the small scale on which the operations were carried out.

The results, however, showed how dependent are the physical properties of wrought tungsten upon the heat treatment and the crystallographic control exercised during the various stages of its manufacture.

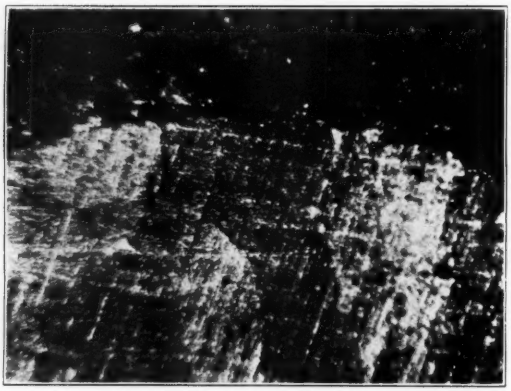


Fig. 29.—Surface, Specimen 28.

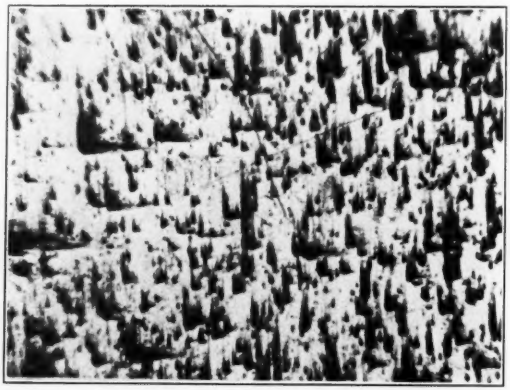


Fig. 30.—First Stage, Compressed Powder.

The best specimens of this series were hammered out to a thickness of less than 0.5 mm. and, altho it was necessary to increase greatly the heating current with increased cross-section of the ingot, the contact resistance was enough to maintain a sufficiently high temperature. As the electrodes approach each other it became increasingly difficult to make accurate temperature measurements, since only the irregular outside edge of the flattened ingot could be sighted upon with the pyrometer.

No means were available with which to draw this material, so that its behavior during that operation, and the influence of the above-described control can only be assumed.

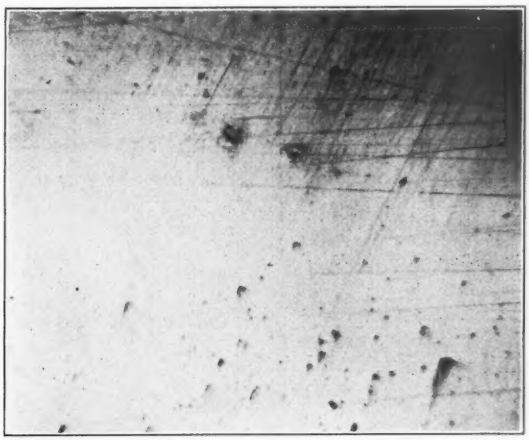


Fig. 31.—Second Stage, Noncrystalline Mass.

Tungsten with 0.75 per cent. Thorium Oxide.—An exactly similar series of experiments revealed only one point in which tungsten and thorium oxide reacted differently from the pure tungsten; but that point is of the greatest importance.

Sintering progressed with the gradual appearance of crystallites in a manner so closely paralleling the preceding case that the presentation of another almost identical set of figures and micrographs is thought unnecessary. But with re-

Fig. 32.—Third Stage, Solid Crystalline Ingot.

spect to the crystal growth at higher temperatures, there was a marked difference. The presence of this small amount of thorium oxide was found largely to prevent a coarsely crystalline formation in highly overheated specimens; and even at stages just below the actual melting point the structure was very uniform. The explanation for this marked influence of thorium oxide is probably as follows:

Crystallization of this powdery, amorphous mass no doubt begins, as in the case of crystallization from the liquid state, at numerous centers, and proceeds, as in that state also, by the impressed orientation and resulting "absorption" of adjacent molecules of amorphous material, accompanied by an expulsion of foreign matter outward until, when neighboring crystals meet, the intercrystalline boundaries consist of thin sheets of this foreign matter. In most known cases the presence of this foreign material produces a weakness in the entire mass, but in the case of tungsten, the thorium oxide seems to be in such form as not only to prevent crystal growth, by its presence among the molecules of tungsten and later, between adjacent crystallites, but to maintain the strength of the entire mass. This may be a phenomenon similar to that which may be caused by iron oxide when two pieces of iron are welded together.[23] It has been noticed, in this case, that no matter how great the crystal growth occurring within either of the welded parts, no growth will extend across the weld; and this weld is usually the strongest section of the specimen.

Several experiments were performed, in which the thorium oxide was replaced by other refractory oxides. Magnesium oxide, cerium oxide, and other refractory earths, produced a similar retarding action upon crystallization, but the effect was not so marked. Altho the experiments on other oxides than thoria were not sufficiently extended to locate these materials on a scale of their comparative effects in retarding the crystallization of tungsten and molybdenum, their value, for this purpose, seems to be a function of the temperatures at which they begin to soften.

The explanation of the accumulation of thorium oxide at the inter-crystalline

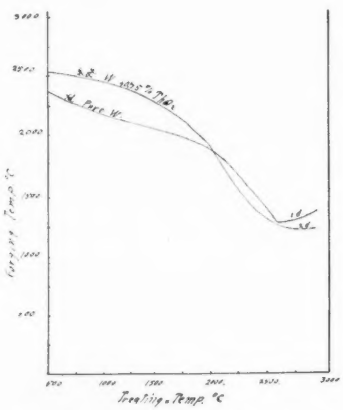


Fig. 33.—Treating and Forging Temperatures for Pure Tungsten and Tungsten Containing 0.75 Per Cent. of Thorium Oxide.

boundaries was first given by Zay Jeffries;[24] and this phenomenon has been observed so often, during studies in connection with these experiments, that the logic of the explanation seems proved. Nothing is known regarding the physical characteristics of this rare earth when segregated under these conditions, but there is no reason for believing that it may not be in a vitreous, amorphous form, and hence, of great strength.

The influence of thorium oxide during forging was not so marked, but this due to the fact that these experiments were

[23]It might be of interest to determine the effect of iron oxide upon the crystallization of iron, and upon its physical properties, by adopting a method similar to that here used for tungsten.

[24]Private communication, 1914.

carried out only to such extent as to prove that this material could be forged under the above condition. Indirectly, however, the effect of thorium oxide was present, in that those ingots formed at the higher temperatures, and in which excessive crystallization had been prevented by its presence, could be forged at the lower temperature, the curve not showing an upturned branch at the high-treating temperature end, as had that for pure tungsten (see Fig. 33).

Pure Molybdenum.—The material used in this series, obtained from the General Electric Co., was the chemically pure powdered metal used in the manufacture of drawn wire.

The raw briquets of molybdenum were made under a pressure of 14,500 kg. per square centimeter and gave an average specific gravity of 7.80. Table IV shows the change in internal structure of briquet with increasing temperatures.

The photomicrographs of this series could not be distinguished, in representing the transition from compressed amorphous powder to crystalline ingot, from those for pure tungsten, and hence are not given.

Specimen No. 23g, was of minimum grain size consistent with maximum crystalline formation. In this, as in the preceding series, it seemed necessary to reach a certain size of grain in order to produce an ingot free from patches of incompact amorphous material, the presence of which made it necessary to use a very high temperature at the beginning of the forging operation. On the other hand, too high a treating temperature produced a coarsely crystalline structure, with its inherent brittleness, which also could not be overcome, except at high temperatures.

The forging curve for pure molybdenum showed a minimum corresponding to No. 23g, with higher temperatures on either side, as in the case of pure tungsten.

The results of experiments on tungsten and molybdenum have given excellent support to the theory upon which the work was based, and furnished details of critical points which promise to be paralleled, and should be searched for, in any series of their alloys.

Having established the soundness of the principles involved when applied to these pure metals, the next step was to apply them to connection with their alloys.

It must be again pointed out that this method did not have as its object the production of true alloys, in the sense of those which solidify from the liquid state, but to avoid such consequences as might result from that condition, by welding together, at a temperature below the melting point, particles of molecular proportions, which should be as

TABLE IV.—Structural Changes in Briquets of Molybdenum.

Specimen Number	Temperature. Deg. C.	Time Hr.	Time Min.	Remarks.
4	400	1	0	Slightly harder and more coherent than raw briquet.
8	800	1	0	Hard enough to be poorly polished.
12	1,200	1	0	Very hard and brittle, but of considerable compressive strength. Polished as solid metal.
16	1,600	1	0	Stronger and more metallic than No. 12.
20	2,000	1	0	Structure changed. Showed patches which microscopically behaved as solid crystalline material, but with no definite boundaries.
22	2,200	1	0	Coarsely crystalline, but with grains of very irregular size.
24c	2,400	0	10	Coarsely crystalline, grains of more regular size than 22.
23g	2,300	0	1	Very finely crystalline. Ingot quite homogeneous thruout, best structure of series.

evenly distributed and uniformly mixed as are the molecules in a true solid solution.

Tungsten-Gold Series.—To insure an intimate mixture of gold and tungsten the chemically pure tungsten metal was first oxidized and then saturated in an evaporating dish with an acid gold chloride solution containing the desired percentage of gold. This was carefully evaporated and dried, with constant stirring to prevent segregation; then transferred to an alundum boat and placed in the quartz tube furnace for reduction under pure hydrogen. This material, when compressed into briquets, under 19,300 kg. per square centimeter (about 265,000 lb. per square inch) pressure and examined under 2,500 diameters, did not show the slightest non-uniformity.

This series was investigated thru a range from 0.1 to 20 per cent. of gold; but to give in detail the numerous negative results obtained would make this paper too cumbersome. A brief description of the behavior of these combinations in several proportions will suffice for the series.

No combination in this series could be forged at any temperature; even 0.1 (which was the smallest percentage of gold used) seemed to be sufficient to prevent working of the mass.

Below 1.4 per cent. the gold could not be detected as segregated at any stage of the treatment. This amount, however, was sufficient to cause coarse crystallization at about 2,500°C. Analysis showed the rather remarkable fact that very little of this gold was lost, even in those specimens which were treated to a temperature of 2600°C., which is far above the accepted boiling point of gold.

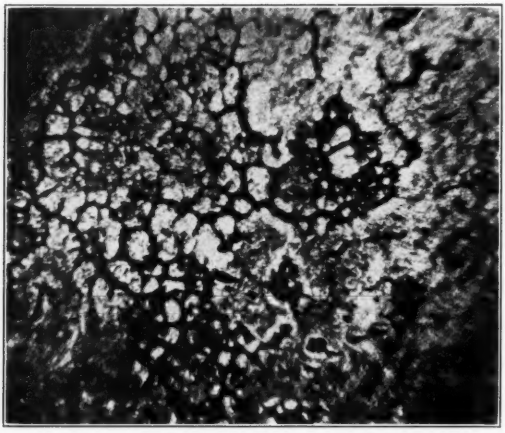


Fig. 34.—Tungsten-Gold Mixture, Containing More Than 1.4 Per Cent. of Gold. Dark Areas, Gold. Etched with Aqua Regia.

The extreme fragility of these specimens at very high temperature prevented even an approximate determination of the melting point.

Above 1.4 per cent. of gold, a segregation resulted in those specimens treated between about 1,200°C. and 2,200°C. (see Fig. 34). Below about 1,200°C. no change could be detected microscopically, while above 2,200°C. a

homogeneous crystalline mass resulted. An interesting phenomenon is noted in connection with temperatures above this latter point. In the case of specimens containing 5, 7, and 10 per cent. respectively of gold, after being heated to a temperature near 2,600°C. the gold content was found to be partly volatilized, and condensed in visible particles on the chamber walls and on the electrodes. In each case there remained a coarsely crystalline mass containing from 4 to 5 per cent. of gold.

No attempt was made to learn the nature of this material or to determine its properties, other than to prove its worthlessness from a mechanical point of view.[25]

Tungsten-Palladium.—A similar investigation of the tungsten-palladium series, but involving only 0.0 to 4.5 per cent. of palladium, gave results very similar to those of the preceding series. Below the melting point of palladium, no change could be detected. Above this point the mass became crystalline and possessed an inherent brittleness which could not be overcome. This was no doubt due to the fact that some reaction had taken place. Whether a compound or solution was formed is not known, but that combination of some kind had occurred, was attested by the fact that the mass appeared homogeneous at all stages of the treatment under the highest magnification.

These ingots of tungsten containing palladium were not found to be malleable, when worked under the above-described conditions.

Tungsten - Molybdenum Series. — The tungsten-molybdenum series was investigated in various proportions of the components, taken at 10 per cent. intervals thru the range from pure tungsten to pure molybdenum. The alloys represented by each of these intervals were found to be susceptible to certain conditions under which they could be wrought. The briquets were made under a pressure of 18,000 kg. per square centimeter and were then treated thru a range of temperature in a manner similar to that employed in the previous series. Figures for the treating and forging temperatures of pure tungsten and molybdenum have already been given, while those for intermediate points are shown on the curves, Fig. 35.

The investigation of this series involved the treatment of more than 200 small ingots, and to give the details regarding each would be merely to repeat those already given for pure tungsten, which may be taken as typical for any of these series. The formation of crystallites and crystal growth proceeds in a manner shown in the photomicrographs of the pure tungsten briquets, altho—and here is an important point—the temperature representing a certain grain size changes with the relative amounts of the components, as the curve clearly shows. This is to be expected, and must be observed, in the treatment of the ingots; but it is not known whether this factor has received consideration in any attempted commercial production of such alloys.

A factor of equal importance is that of a corresponding change in the temperature of forging. If, for instance, only 1

[25] It would be interesting to try this method upon combinations of metals such as nickel and palladium, copper and gold, or a similar series, whose components were of nearly equal melting point; for the failure to produce results in the case of gold and palladium with tungsten may be ascribed to a too great difference between melting points of the components. Near the lower range, the tungsten is not sufficiently plastic to permit a welding between the particles; while at higher temperatures, fusion conditions are present.

Even the pure metals, as gold, copper, iron, etc., might, if prepared in this way, possess properties far superior to those of the cast and worked metals, for in this manner the mass may be made to consist more completely of amorphous material, with its attendant characteristics, as shown in the results of experiments on pure gold, as described above. Even tho an entirely amorphous condition could not be maintained thruout the operation, at least a much more finely crystalline ingot might result than from any available fusion method.

Experiments have been started with the view of testing this out, but have not progressed to that stage which would permit a definite statement regarding this possibility.

per cent. of molybdenum were added to the tungsten, a treatment identical with that for pure tungsten would produce grains of such large size that even after repeated forging (and this requiring a higher relative temperature) the material would still be unreliable. On the other hand, the addition of small amounts of tungsten to molybdenum would necessitate higher treating and forging temperatures, as shown in Fig. 35.

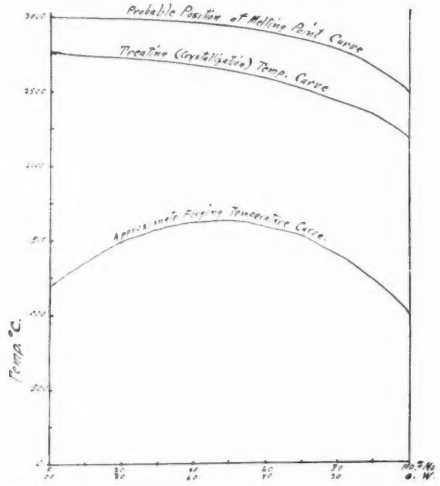


Fig. 35.—Treating and Forging Temperatures of Tungsten-Molybdenum Series.

Microscopical examination of these treated specimens revealed nothing that would indicate that these two metals formed other than a complete series of solid solutions; and if the crystallization curve may be taken as paralleling the melting-point curve (which assumption seems not illogical), then this latter curve will be found, when determined, to occupy a position approximately as indicated in Fig. 35.

Fig. 36 shows a specimen of the 50 per cent. alloy as the raw briquet and after being forged; while Fig. 37 shows a microsection of this same specimen, after treating and before forging.

VI. SUMMARY AND CONCLUSIONS.

With regard to the degree of accuracy with which temperatures could be measured in these experiments; it must be pointed out that the object was not to establish these critical points for direct transference to any commercial plant (for different types of apparatus would necessitate a determination of these conditions to suit each individual case), but to determine their existence and influence. It would also be of no avail to locate these critical ranges because every different set of apparatus and conditions would require a new standardization.

In these experiments, however, the temperatures necessary to produce a certain degree of crystallization were considered as being located with a fair degree of accuracy, insofar as this may not be qualified by the existence of working conditions which were far from ideal.

As to the measurement of forging temperatures, no claim is made for more than close approximations, for this was properly not a one-man operation, and was performed by the writer with one eye to

the optical pyrometer the other on the milliammeter scale; one hand on the

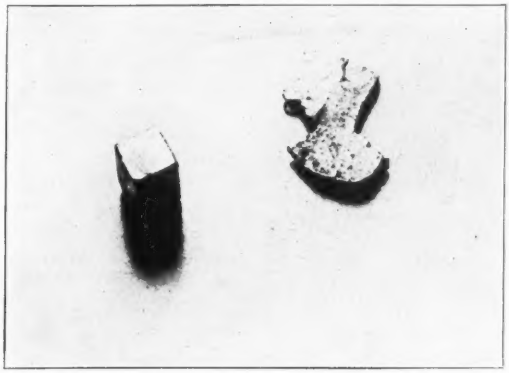


Fig. 36.—Raw and Forged Briquet of 50 Per Cent. Tungsten-Molybdenum Alloy.

pyrometer rheostats, the other using a hammer on the upper electrode; while the heating current was controlled by one foot on a lever regulating the transformer and rheostat.

The experimental work resolved itself into three parts, each being marked by a different method of attack, necessitated by limitations encountered as the work progressed under previously adopted methods.

The first part considered of experiments on binary combinations of those of the metals which it was feasible to consider, and the melting points of which lay within the limits of ordinary fusion

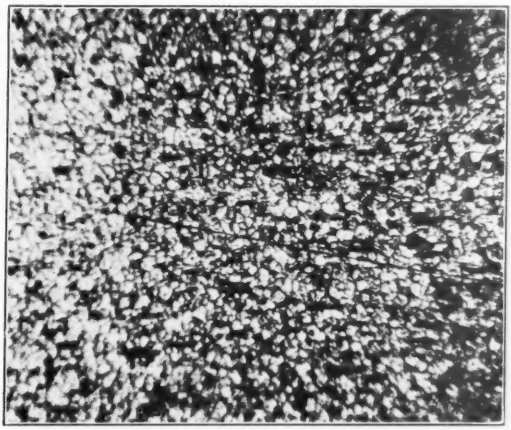


Fig. 37.—Microsection of Briquet, Fig. 36, after Treatment and Before Forging.

methods. The results of these experiments, performed as indicated therein, lead to the conclusion that metals or alloys of metals outside of the precious-metal groups, are unsuitable as substitutes for platinum.

The gold and silver alloys of palladium have been found to be excellent substitutes for platinum in its softer forms, and while not so chemically resistant, fill all requirements where conditions are not too rigid.

The second part develops the fact that except in two respects, pure ductile tungsten, and, to a lesser degree, molybdenum, meet all of the specifications of a practical substitute for platinum and its alloys. These two defects are its ease of oxidation, and the difficulty with which it can be soldered; and they have been overcome by coating with a precious metal or alloy, the resulting material being in many ways far superior to platinum or its alloys.

This material has met with instant demand, is in many cases replacing the best platinum-iridium alloys, and permits the performance of work which has been impossible with the materials hitherto available.

The third part describes the theoretical and practical considerations involved in the manufacture of wrought tungsten and molybdenum, and gives results of the proper application of a similar method in the laboratory production of their alloys.

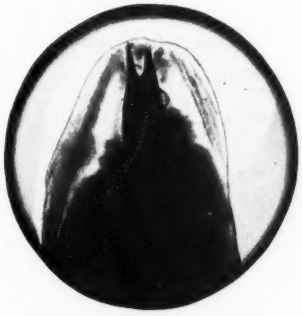
Wrought tungsten and molybdenum were produced on a laboratory scale, but no success attended the attempted production of alloys of tungsten with gold and palladium; while on the other hand, the alloys of the tungsten-molybdenum series were produced in wrought form. These operations were governed entirely by metallographic control, and their success suggests the possible application of a similar method in a treatment of such metals as iridium, tantalum, rhodium, osmium, etc., in combination with each other, or with tungsten or molybdenum, which may result in the production of alloys possessing properties far superior to those of any material now available.

MULTIPLE APICAL FORAMINA OF TOOTH ROOTS.

By Dr. J. R. Callahan, Cincinnati, Ohio.
(Special Research Director for the Research Institute of The National Dental Association in the Cincinnati General Hospital.)

IT IS essential to the proper understanding and treatment of foci of systemic infection arising from the pres-

Figure 1.



Apical third of an adult Cuspid tooth.

ence of infected pulp tissue confined within the root canals of devitalized teeth, that the anatomy of the root ca-

Figure 2.

Apical third of Anterior Root of Inferior Molar.

nals of human teeth be more thoroly understood.

Anatomical text books mention and illustrate the foramen, "which transmits the afferent and efferent blood vessels and terminations of the nervous system of the pulp."

Three or four years ago Fischer discovered what appeared to be multiple foramina. Later Feiler shows by removing cemental tissue from root ends with sand paper disks that the multiple foramina of Fischers were canals or holes in cemental tissue produced by the action of antiforamen, a powerful solvent of organic substance.

The surface of root ends so treated show that these minute canals or holes do not connect with the pulp canal, therefore are not true dental foramina.

The accompaning photomicrographs show clearly what I have for three years,

Figure 3.

Root end of Cuspid tooth—Adolescent.

in papers on root canal fillings, referred to as colatteral root canals and multiple foramina.

Figures 1 and 2 are ground sections of teeth from which the pulp tissue was removed. The canals were then filled with stained rosin solution. The stained rosin solution enters the tubuli, therefore the dentine as well as the collateral canals show dark. Figure 3 is a ground section from a tooth which pulp tissue was removed. The tooth then placed in Hamatoxylin stain over night.

This speciman shows a rather frequent collateral branching of the root canals in cuspid teeth. I am not yet prepared to say in what percent of teeth these lateral canals occur.

LEGISLATIVE DEPARTMENT.

PRESENT STATUS OF DENTAL LEGISLATION.

By Homer C. Brown, D.D.S., Columbus, Ohio.

Columbus, O., March 22, 1916.

The latest information is as follows: House Bill will probably pass within a few hours and Senate Bill will receive prompt consideration. Senator Pomerene, of Ohio, will attempt to get three amendments to the Army Dental Corps provisions of Senate Bill 4840. First, actual rank or the three grades provided in this bill; second, provision for dental representation on examining and review boards; third, an amendment that will reduce the length of service required for promotion. We have sent these to him and emphasized the order of importance, with the understanding that he only present such as will have the approval, or at least no strong opposition from members of the Military Affairs Committee and particularly Senator Chamberlain.

If we secure the first two we should feel well satisfied, and if only the first, it will give us an excellent opportunity in conference committee. It is generally understood that the chairmen of the respective military committees, Senator George E. Chamberlain, of Oregon, and Congressman James Hay, of Virginia, together with the ranking members of each political party, constitute the conference committee. This would make it Senators Gilbert M. Hitchcock, of Nebraska, and Henry A. DuPont, of Delaware. In addition to Mr. Hay, the other House conferees will be Hon. S. H. Dent, of Alabama, and Hon. Julius Kahn, of California. If there are any changes in the members of this conference committee, our members can ascertain this thru the press when the committee is appointed.

We urge that our readers from the states represented in this conference committee, promptly wire or write their member on committee, requesting that actual rank with three grades and dental representation on examining and review boards be provided for the Army Dental Corps.

THE Senate National Defense Bill, introduced by Senator Chamberlain March 4th, and amended in Committee and reported March 16th. This bill is known as S. 4840 and was prepared by the Senate Committee on Military Affairs and contains the provisions for the Army Dental Corps, as follows:

"The President is hereby authorized to appoint and commission, by and with the advice and consent of the Senate, dental surgeons at the rate of one for each one thousand enlisted men of the line of the

Army. Dental surgeons shall have the pay and allowances of first lieutenants until they have completed ten years' service. Dental surgeons of more than ten but less than **twenty-five** years' service shall, subject to such examination as the President may prescribe, have the pay and allowances of captains. Dental surgeons of more than **twenty-five** years' service shall, subject to such examination as the President may prescribe, have the pay and allowances of major: Provided, That the total number of dental surgeons with pay and allowances of major shall not at any time exceed fifteen: **And provided further, That all laws relating to the examination of officers of the Medical Corps for promotion shall be applicable to dental surgeons."**

H. R. 12766 is a similar bill introduced in the House March 6th by Mr. Hay, Chairman of the House Committee on Military Affairs. This bill is as follows: "Provided further, That hereafter the Dental Corps of the Army shall consist of the number of officers in said corps now provided by law, and that there shall be thirty-five captains in said corps; that appointees to the grade of first lieutenants in said corps shall be not less than twenty-two years and not more than thirty years of age; and that promotion to the grade of captain, herein provided for, shall be subject to an examination before a board consisting of not more than three officers of the Medical Department, including the Dental Corps of the Army, to be appointed by the Secretary of War; and that the captains provided for in this Act shall be appointed from the present members of the Dental Corps who have had five years service in said corps."

Neither of these bills are as liberal in their provisions as had been anticipated. On the other hand both bills indicate that there is a willingness upon the part of those particularly interested in Military Affairs in Congress to improve the conditions of the Army Dental Corps. In one sense, the provisions of the Senate Bill are better than those of the House Bill, especially so if a construction "appoint and commission" is construed to mean "commission with rank, etc." Some contend that this is what this phraseology means. If so it would seem that there should not be much trouble in having this phraseology corrected to read "dental surgeons shall have the **rank,** pay and allowances, etc.," instead of "pay and allowances." There is no question about the meaning of the suggested phraseology and we are in hopes that this can be satisfactorily substituted, either in committee or on the floor of the Senate. The Chamberlain Bill was referred back to the Senate Military Committee, while the House Bill was referred to the Committee of the Whole House.

The House Bill provides actual rank for first lieutenants and thirty-five captains. We hope that Chairman Hay will agree to the increasing of the provisions of this bill to include majors. With this in view, representatives of the committee and officers of the association are to meet in Washington March 16th as our legislation is in a critical situation and we appreciate that whatever is to be done must receive prompt attention and be handled as diplomatically as possible; by this I mean that we will not be justified in attempting to secure more than we can get the chairmen of the two Military Committees to approve, since they have been very considerate of our interests and this should be fully recognized as well as the fact that the attempt to go further than they will support may jeopardize the increase that is carried in these two bills. Whatever difference exists in the Senate and House Bills, as they may pass their respective branches of Congress, will necessarily have to be adjusted thru a Conference Committee. This committee will consist of: Senators George E. Chamberlain (Oregon),

Gilbert M. Hitchcock, (Nebraska), Henry T. DuPont (Delaware), and Congressman James Hay (Virginia), S. H. Dent, (Alabama), and Julius Kahn, (California). These names are given in this connection so that our members of these states may be fully advised with reference to their opportunities and responsibilities if any very great differences exist in these two bills when they reach the Conference Committee. If so, we will promptly advise State Dental Society officers in these six states and will certainly expect that they use their best possible influence, both professionally and politically, to the end that the bill giving the best recognition shall be reported out by this committee.

This article is being written March 14 and with a view to giving our membership the latest information relative to the legislative program. Dr. King is to meet me in Washington Thursday and undoubtedly we will arrange to briefly incorporate any specific instructions thought necessary to further advance any definite course that may be thought best to adopt following this visit to Washington. There is absolutely no hope of securing a Colonel as the head of the Dental Corps, and in the face of recent developments, it looks as tho it is impractical to expect provisions to be made for the Dental Reserve Corps. Explanatory, in the House Bill provision is made for the elimination of the Medical Reserve Corps after one year. The members of this corps are then to be transferred to the Officers Reserve Corps.

The above relates to the present status of our legislative situation and the recommendations of the Legislative Committee will be incorporated in what we will term the "Past efforts or the development of our Legislative Program," which is responsible for what has just been outlined. The following will give those interested a better idea of our activities in this legislative question and will show the committee's reasons for not introducing an Independent Bill.

PAST EFFORTS.

The House of Delegates, at both the Rochester and the San Francisco meetings, unanimously endorsed a specific Legislative program and instructed the Legislative Committee to use its best efforts to have same favorably acted upon by Congress. This committee, assisted by representatives from the Army Dental Corps, prepared a bill which was incorporated in the committee's report at San Francisco, and will be found on Page 380 of the November issue of the National Journal.

The question of having this bill introduced in the Sixty-third Congress was taken up with prominent respresentatives in Congress, especially those active and influential in congressional military affairs. They definitely presented reasons why the proposed bill should not be introduced as an amendent to the Appropriation Bill at that time, as was urged by some, as there was absolutely no hope of securing said legislation without the approval of the committee to which such questions would naturally be referred. We followed this advice because it conformed to the convictions of some members of our committee and by so doing we were promised support during the present session of Congress, **and be it said to the credit of these men that they have kept their promises. In fact, had it not been for this support we would not have received the recognition we have thus far secured.**

A meeting of the Legislative Committee was held in Washington November 3rd, 1915, with Drs. Herbert L. Wheeler, A. O. Ross, C. B. Gifford and Homer C. Brown present. (Dr. Charles R. E. Koch was unable to attend on account of an important engagement.) Drs. E. P. Tignor and S. D. Boak of the Army Dental Corps, met with us and rendered valua-

ble assistance. We thoroly canvassed the situation and in view of a general recognized policy to reorganize the entire military affairs of our country we all agreed that our best course would be to endeavor to have our recommendations incorporated in the general reorganization program and if possible presented by some of the department heads.

Or at least we should concentrate our efforts upon the Senate and House Military Affairs Committees, so that when the bills from these committees were formulated they would accord us the highest recognition we could secure thru them. To that end we conferred with the Honorable Secretary of War, the Chief of Staff and the officials in the Surgeon General's Department. (We had a tentative appointment with the Surgeon General but he had been called out of the city), and the chairman of the Senate and House Military Affairs Committee. We also called upon the Honorable Secretary of Navy, the Surgeon General of Navy and the Quarter Master General of the Army. We presented our cause orally and received courteous treatment from all. They were attentive and seemed interested in the cause presented. At the request of the Secretary of War, we hastily prepared and presented, the next day, our recommendations and some brief arguments. (See hearing before House Military Committee on this page).

We furnished similar copies to the others heretofore mentioned and requested that our committee be granted an opportunity to present further arguments before the Military Committee of both branches of Congress. In addition to this, our efforts were largely directed in interesting members of the Senate and House Military Affairs Committees.

On January 27th the following telegram was received from Senator Chamberlain:

"Dr. Homer C. Brown, Chairman,
Columbus, Ohio.

If you so desire Senate Committee on Military Affairs will hear one or two representatives of the Dental Association Wednesday morning, February 2nd, to present testimony relating to Army Dental Corps.

(Signed):
GEORGE E. CHAMBERLAIN."

To which reply was made:

"Senator George E. Chamberlain,
Senate Chamber.

Thanks for wire advising hearing of Dental Corps matters, February 2nd. Representatives of our committee will be present. Hope House committee may hear us on same day and am wiring Chairman Hay to that effect. Any arrangements for time satisfactory to both of you will suit us.

(Signed):
HOMER C. BROWN, Chairman."

A similar telegram, in conformity to above, was sent Mr. Hay but he wired that we could not be heard until February 8th. However, we were anxious to make one trip suffice and wrote some others in Congress and Dr. Gifford and myself conferred with Chairman Hay, soon after our arrival, and he very kindly consented to a change in his program and heard us, together with Dr. Tignor, the following day.

The following is from Congressional Records: (Similar hearing before Senate Committee Feb. 22, Part 17.)

HEARING BEFORE THE COMMITTEE ON MILITARY AFFAIRS

House of Representatives, Sixty-fourth Congress, First Session, on the Bill to Increase the Efficiency of the Military Establishment of the United States.

Committee on Military Affairs,
House of Representatives,
Thursday, February 3, 1916.

The Committee this day met, Hon. James Hay (chairman) presiding.

Statement of Dr. Homer C. Brown, 185 East State Street, Columbus, Ohio, Chairman Legislative Committee National Dental Association:

THE CHAIRMAN. Dr. Homer C. Brown, the chairman of the Legislative Committee of the National Dental Association, desires to be heard in reference to an increase in the Dental Corps, and we will be glad to hear him at this time.

DR. BROWN: Mr. Chairman and gentlemen of the committee, I do not expect to detain you long, as I only desire to state briefly the reasons why the members of the National Dental Association, and the profession generally, advocate a greater efficiency and the raising of the status of the Army Dental Corps.

In order to qualify as an accredited spokesman for the dental profession and to better indicate my familiarity with our affairs generally, will say it has been my privilege to serve for five years as Secretary of the National Dental Association, two years as Corresponding Secretary and three years as Recording Secretary. Was later unanimously elected the first President of our reorganized National Dental Association, so that I think you will appreciate that I have been and am in fairly close touch with the profession of our country.

As chairman of the Legislative Committee of the National Dental Association, I appear before you, thru the courtesy of your chairman, in behalf of legislation which has for its purpose the increasing of the efficiency and raising of the status of the Army Dental Corps, which will, at the same time, secure for our profession recognition appropriate with the service rendered.

"Necessity is the mother of invention." This statement is frequently used and is especially applicable in this connection, since it was during the War with Spain that the necessity for dental treatment of soldiers was very emphatically demonstrated. In order to meet the pressing needs at that critical period, some of the younger members of our profession, imbued with patriotic impulses and anxious to serve our country in any capacity, enlisted and were assigned to the Hospital Corps in order to render such dental services as the exingencies of the situation would permit. I very distinctly recall a young man from the small town where I practiced, and with whose parents I boarded, enlisted under these conditions the day following his graduation and leaving immediately for the front. A few months later I was called upon to officiate as one of his pall bearers. This personal reference is only made to indicate my familiarity with the conditions existing at that time, and it has been my privilege to keep in rather close touch with all the developments in this connection since then.

In 1901 Congress passed a law creating a corps of 30 contract dental surgeons, attached to the Medical Corps, but without military rank. The late General Sternberg was Surgeon General of the Army at that time and accepted, as a compromise, the contract status as only a temporary expediency, giving assurance of his support in securing legislation which would commission these men during his term of office. Some who entered the service at that time were encouraged to do so with that definite understanding.

Congress passed a law March 3, 1911, granting one commissioned grade—that of first lieutenant. This law also made possible a Dental Corps on a basis of 1 to 1,000 of the actual strength of the Army, but at present there as only 36 first lieutenants to 39 acting dental surgeons in the Army Dental Corps. One reason which may be responsible for the fact that this has not been filled to its possible apportionment is that the opportunities are not sufficiently attractive to many of the graduates today.

Further, it may be of some interest to have data relative to the results of the

examinations for the Army Dental Corps from September 1, 1911, to October 18, 1915. During this period 377 were notified to appear for examination. Twenty-eight of this number declined the invitation and 85 failed to present themselves for the examination; 55 were disqualified by physical examination and 146 failed to pass the required examination, leaving 63 that met all the requirements.

During the 15 years since Congress passed legislation granting the first Dental Corps the progress and achievements of the dental profession have attracted most favorable attention from all sources, until it is now recognized as assuming its full responsibilities in the educational campaign of preventative medicine, which is generally and generously considered both a humanitarian and an economic question.

If organization will be accepted as an evidence of progress, I need only say that four years ago the membership of our National Dental Association was not in excess of 800, but since then it has been reorganized, and today has a membership of nearly 20,000 of the most progressive and aggressive dentists of the world. Less than nine months ago the research institute of this association was incorporated in Ohio to carry on research work along lines similar to the Rockefeller Institute and the Carnegie Foundation. Our own building, adequately equipped, is to be formally opened on Tuesday night, February 7, with some of the most noted members of the medical, dental, and allied professions present. The funds for this work have largely been provided by our members. The dentists of my State—Ohio—have contributed nearly $20,000, and, be it said to the credit of the members of the Army Dental Corps, that they have liberally contributed to this research work.

These general remarks may seem unnecessary on this occasion, but are made for the sole purpose of impressing you with the fact of the changed attitude toward the dental profession in the past few years. All of this has stimulated the hopes and aspirations of the dental graduates of recent years, and when associated with the increased educational requirements and the necessary additional expense in completing a dental college course, as well as the fact of the limited purchasing power of the dollar of today as compared with a few years ago, it makes it easily understood why it is necessary to provide some positive changes for the betterment of the Army Dental Corps.

Further, the present European was has demonstrated the close relation of the work of the medical and dental professions, and the work of the dental surgeon in the present war has attracted favorable attention thruout the world. In this connection I quote from Dr. A. M. Fauntleroy, surgeon of the United States Navy, in his report of the medico-military aspects of the European war.

I would respectfully refer the members of this committee to the book entitled "Medico-Military Aspects of the European War," to which I have no doubt all of you have access, and which will enable you to better understand why I consider this work so important.

MR. LITTLEPAGE. That book has been sent to a good number of us. I have one.

DR. BROWN. I think it is a very interesting report, and it will show clearly the importance of what I have said with reference to the European war developing certain conditions or methods of warfare which necessitate the thoro cooperation of the medical and dental men in all of these matters.

MR. KAHN. Is that book published by the Navy Department.

DR. BROWN. Yes, sir. Dr. Fauntleroy, in his report, says:

One of the surgical advances of the present war has been the recognition of

the dentist as a necessary unit in the organization of a military hospital. It has been largely brought about by the present-day trench warfare. The latter leads to the production of a large number of face and jaw wounds, involving either a great loss of substance in the form of bones, teeth, and soft parts. So valuable has this work become that every large military hospital now has its surgical dental department which works in conjunction with large surgical services and supplements certain procedures which are indispensible as regards bringing about a favorable result. * * * One of the most attractive features of the value of the dentist in the organization of a military hospital is shown in the results obtained by surgical co-operation with the dentists at the American ambulance in connection with the mutilated wounds in the face.

In this connection I am reminded of a conversation I had only last Saturday with the Hon. Myron T. Herrick, one of Ohio's foremost citizens, who recently rendered most efficient and commendatory service as ambassador to France. He informed me that he very early recognized the need for dental services in connection with the American ambulance, and did everything possible in establishing this particular service. Coming from a layman, and a man of Mr. Herrick's standing, this observation is entitled to your most careful consideration.

Further, Dr. George W. Crile, who needs no further introduction, and Dr. W. E. Lower, president of the Ohio State Medical Association, both informed me soon after their return from service in connection with the American ambulance in Paris, that the work of the dental surgeons in connection therewith was receiving the highest possible commendation, and would result in bringing about a closer relation of the two professions, and the raising, very materially, of the standard of dentistry in the eyes of the world.

In the last copy of the Army and Navy Register, we note, in connection with Gen. Gorgas's appearance before your committee, the following:

Information was sought concerning the Dental Corps, and it was announced that the new legislation, approved by the War Department, contemplated promotion for dental surgeons up to and including the grade of major; that there were increasingly important functions for dentists in the military service; that the dentists were doing splendid work in Europe; that there was an important function in dental surgery on account of special wounds. Gen. Gorgas added that on a recent trip to Canada he had occasion to inspect a new command destined for service in Europe and found it equipped with an excellent dental department and that men were now being accepted for service despite dental defects which hitherto would have resulted in their rejection.

In this connection you understand that a man applying for enlistment must necessarily undergo a physical examination, and he must have a stipulated requirement of masticatory surface before he is accepted. And, as Gen. Gorgas has indicated, the fact of having the dental corps up to a high standard makes it possible to take into the service men who would otherwise be disqualified.

You may be interested in knowing that our committee has not taken a position of attempting to go headstrong and independent in an effort to secure what appears to our profession as meritorious legislation. On the contrary, we have respectfully and considerately presented our views to the honorable Secretary of War, the Surgeon General, and the chairmen of the Senate and House Military Affairs Committees, and it is indeed very pleasing to note the published comment to which I have just referred.

With reference to the other countries, I want to say that just before reaching Washington yesterday morning, Col. Barger, of the Ohio National Guard—and Ohio seems to be very well represented on this occasion—referred to the

number of Ohio men present interested in the subject of military preparedness.

MR. LITTLEPAGE. It is very ably represented on this committee.

DR. BROWN. I appreciate that fact and I acknowledge my deference to my native State, West Virginia, as I believe you represent a district of that State, Mr. Littlepage?

MR. LITTLEPAGE. Yes; I do.

DR. BROWN. Col. Barger called my attention to an article appearing in the Literary Digest of January 29, in which reference is made to an article written by Prof. William H. Potter, of Harvard University.

THE CHAIRMAN. You may put that in the record.

DR. BROWN. I thank you, Mr. Hay, but will only briefly quote as follows:

A large proportion of the earliest English volunteers in the present war had teeth so defective that they could not chew army rations and had to be sent back from the firing line. On the other hand, Germany long ago recognized the necessity of good teeth for the soldier, and no small proportion of her military efficiency is due to this fact.

Dr. Potter indicates that the service of the military dentist should begin with the soldiers long before they are sent to the front. It is of the greatest importance, he says, that their teeth should be put in good condition in order that disabling pain may be avoided and that they may be able to chew army rations. Where this work is arranged as a part of the military equipment and is continued several years the best results are obtained. He goes on:

Of the nations now engaged in the great war, Germany has given the most systematic attention to the teeth of its soldiers. She found only 15 years ago that the efficiency of soldiers was seriously impaired when they could not chew hard food and set about to remedy the matter by providing dental clinics for school children, so that boys upon entering the army should present themselves with teeth able to do the work demanded of them. This is one reason why her soldiers are now so efficient.

Supplementing the reference that has been made to the dental corps in the European war, I have recently seen it stated, upon seemingly good authority, that Germany has 800 dental surgeons in the active service. A very late press report indicates that France is planning to add 1,000 additional dentists to her present equipment. I have no specific data relative to the numbers in service in the other countries, but do know that they have met similar conditions and are giving equal attention to the dental needs of their armies.

The National Dental Association is on record as unanimously indorsing the following, which it was my pleasure to recommend in my address as president of the association in 1914.

First. A dental reserve corps, similar to the Medical Reserve Corps, to replace the present "acting dental surgeons," except that members of the dental reserve corps shall be obligated to serve when called upon for active duty.

Second. The Dental Corps to consist of:

(a) First lieutenants, to be appointed from the dental reserve corps after two years of active service, who shall not be less than 23 nor more than 30 years of age and otherwise qualified as at present.

(b) Captains, who shall be promoted to this grade after seven years of total service, including service in dental reserve corps and as contract dental surgeon, dental surgeon, or acting dental surgeon.

(c) Majors, not to exceed 25 per cent of the Dental Corps, to be promoted according to seniority, as in the Medical Corps.

(d) A colonel, who shall be Chief of the Dental Corps, acting under the direction of the Surgeon General, to be appointed by the President, by and with

the advice and consent of the Senate, for a period of four years. The first colonel to be appointed from the 15 senior officers of the Dental Corps, after which they shall be appointed from the majors of this corps.

Third. The strength of the Dental Corps to be as now provided (1 to 1,000 of the enlisted strength.)

Fourth. The service heretofore rendered as dental surgeon, contract dental surgeon, or acting dental surgeon shall be computed as commissioned service.

Fifth. The right to command shall be limited to the members of the Dental Corps and the dental reserve corps and to enlisted men serving as their assistants.

Some of the arguments in support of our recommendations are as follows:

First. The same necessity exists for changing from the contract status (acting dental surgeons) to a commissioned personnel, as resulted in abolishing the contract surgeons in the Medical Surgeons in the Medical Corps. Under contract the dental surgeon occupies an anomalous position, being neither an officer nor an enlisted man, and having no protection in case of disability in the line of duty. In the highly specialized condition of modern warfare economy demands that the enlisted man be in a good physical condition in order to render efficient service, which requires the service of a dentist as well as a physician. Therefore, it is manifestly essential that the service be made equally attractive, as with Medical Reserve Corps.

We are not asking any special favors. We do not feel if any of our profession should be honored by being called into the dental reserve corps and permitted to enjoy favorable conditions until their services are needed and then let them have an easy way of escape. But if they accept service as members of the dental reserve corps, we certainly would expect them to render service to the Nation in time of trouble. We do not want them to be excused from duty if called upon, as is the case in the Medical Corps.

In discussing this question with a gentleman yesterday I referred to the necessity of having the mouth in a healthy condition and not in a condition such as would handicap the individual in using it for the special purpose intended. It is just as necessary to have the mouth in a healthy condition as it is to have a carbureter on an automobile properly adjusted in order to have the car run smoothly, unless it be a Ford, which they say, can run some distance on its reputation.

Second. The age limit has been raised from 27 to 30 on account of the increased preliminary requirements before entering a dental college and an additional year being required in the study of dentistry.

In addition to this, I wish to explain that before a young man can enter a dental college he must have secured a stipulated preliminary education. Commencing next year he must also spend an additional year in a dental college before graduation.

The importance of dentistry is looked upon now in a very different way from that in which it was looked upon when I was in dental college, and the necessity for thoroly equipping a man for that important service and preparing him to intelligently co-operate with the medical man is receiving full consideration, and that is the reason for increasing the requirements and raising the age limit from 27 to 30 years.

Third. It is the conviction of our committee that an increase in the number of grades as suggested will go far toward increasing the efficiency of the Dental Corps. Under existing conditions there is not a sufficient incentive, with present college requirements, to prompt our best dental graduates to enter the service.

Fourth. With an increased Dental Corps, and in the interest of efficiency and economy, there is every reason for having the representative of the corps, with rank of colonel, stationed in the Surgeon General's Office to co-operate with him in the administrative affairs of the Dental Corps.

In this connection I would supplement what I have said by saying that if the Dental Corps is increased in keeping with what seems to be the general concensus of opinion regarding the future strength of the Army, then the Dental Corps will have to be very materially strengthened and the duties of this particular officer would be emphasized.

The purchasing of equipments and supplies, the assignment of the various members of the corps, and all such details could be very much more economically administered, I believe, if there was a Dental Corps officer who was thoroly trained and familiar with the requirements, and who had advanced from the lower rank to the highest position in the corps.

Fifth. The right to command by virtue of a commissioned corps, with actual rank, can not conflict with any other department, and this right can be limited by Congress to the Dental Corps and their enlisted assistants.

Mr. Chairman and gentlemen, in behalf of our committee and the dental profession of the country, I thank you for the opportunity of presenting these arguments, which seem to us to merit your careful consideration.

STATEMENT OF FIRST LIEUT. EDWIN P. TIGNOR, DENTAL CORPS.

THE CHAIRMAN. Doctor, you are a first lieutenant in the Dental Corps of the Army?

DR. TIGNOR. Yes, sir.

THE CHAIRMAN. Doctor, have you made a computation showing how much this increase in the Dental Corps of the Army would cost?

DR. TIGNOR. During the first year the increase would cost between $18,000 and $21,000.

THE CHAIRMAN. How much would it finally cost?

DR. TIGNOR. The final cost of the increase would be about $30,000. The increase would be very gradual, by the addition of two or three thousand a year, the present strength of the commissioned personnel of the Dental Corps being 60, would make the final increase of about $30,000. The increase would be that amount if the present ratio is kept —1 dental surgeon to 1,000 of the enlisted strength.

THE CHAIRMAN. If we have an Army of 134,000 men, there would be 134 dental surgeons in the Dental Corps?

DR. TIGNOR. That is correct.

THE CHAIRMAN. I understand from what Dr. Brown said that you desire that one-fourth of the corps shall have the rank of major?

DR. TIGNOR. Yes, sir.

DR. BROWN. Not to exceed one-fourth.

THE CHAIRMAN. Is that not rather a large proportion?

DR. TIGNOR. It is smaller than the majority of the staff corps at the present time, and that proportion is necessary in order to give promotion in a reasonable number of years. Even in that case, a man promoted to the rank of major would have served possibly 20 years before he reaches that grade. I believe there is but one staff corps in the service at the present time that has a smaller percentage, and I think that is 24 per cent.

MR. GORDON. Which corps is that.

DR. TIGNOR. The chaplains.

THE CHAIRMAN. Doctor, what is the rank of the dental officer in the

French and the German and the English Armies, if you know?

DR. TIGNOR. I do not know what it is in those armies, but I know what it is in the Canadian Army.

THE CHAIRMAN. What is it in the Canadian Army?

DR. TIGNOR. In the Canadian Army the dental surgeons rank from colonel to first lieutenant. The senior officer is a colonel, and the other officers are either lieutenant colonels, majors, captains, or first lieutenants.

THE CHAIRMAN. Your idea in having the head of the corps a colonel is o have some one attached to the Surgeon General's Office who is familiar with the purchasing of supplies and the general run of your profession; is that the idea?

DR. TIGNOR. Yes, sir. I think it is just as necessary, in order to have that efficient corps to have a head who will co-operate with the Surgeon General, and to have in that position somebody who is thoroly familiar with the needs of the corps.

I do not believe it is possible to secure the greatest efficiency without some head of that kind. I think the proposition is the same as it would be with any other organization. I do not believe for instance, that your committee could get along without a chairman and do good work. In our corps at present the individual members have no one who is as thoroly familiar with their needs as a member of their own profession would be.

THE CHAIRMAN. The duties of this corps are now confined and will be confined entirely to the practice of your profession?

DR. TIGNOR. Yes, sir.

THE CHAIRMAN. You now receive $2,000 a year?

DR. TIGNOR. Yes. sir.

THE CHAIRMAN. And you have commutation of quarters?

DR. TIGNOR. Yes, sir.

THE CHAIRMAN. And fuel and light and all the other things which the officers receive?

DR. TIGNOR. Everything that goes with the pay of a first lieutenant.

THE CHAIRMAN. Your puropse in advocating this increase in rank is to secure greater efficiency?

DR. TIGNOR. Yes, sir. At the present time I am on the examining board for the admission of men into the service and I have been on those boards since the corps was reorganized in 1911, and it has been exceedingly hard to get men to come into the service. It is only thru personal contact of the members of the corps with other members of the profession they have been able to persuade men to come into the service and we have not been able to get the men we want. Of course, we could get young dentists who would come into the service, as we could get men in any other department, but we can not get the number of men we want of the type of men we desire.

THE CHAIRMAN. Are the standards of your examinations high?

DR. TIGNOR. We try to keep them high.

THE CHAIRMAN. Who prepares the questions for those examinations?

DR. TIGNOR. They are prepared by a board composed of one medical officer and two officers of the Dental Corps.

THE CHAIRMAN. Is there anything else you desire to say, Doctor?

DR. TIGNOR. I would like to say that in the war in Europe, the modern methods of fighting—trench warfare—expose the head and face of the man, and the result is that there are a great many gun-shot wounds of the jaw. The popular

consensus is that that work is not the work of the dental surgeon, but that it is the work of the general surgeon, but it is not

The work of an oral surgeon is not confined to the teeth It takes in the whole oral cavity, the whole mouth, and his services are required there as much as they would be in time of peace in preparing a man to preserve his health.

I would like to say another thing, and that is that it is generally recognized now that a great many of the diseases to which the human system is heir originate in the mouth, and that probably the most important part of our work is preventive.

By treating conditions as found in the mouth you remove the focus of infection, and it has been stated that the fact that the American ambulance in Paris has been able to treat the wounded and send them back on duty in so short a time, averaging about two weeks, has been due principally to the fact that the men received dental treatment as soon as they reached the hospital, and the oral infection has been removed, and that has enabled their wounds to heal quicker.

MR. McKENZIE. Are the dental surgeons of the Army required to devote all their time to the services of the Army?

DR. TIGNOR. Yes, sir.

MR. McKENZIE. They are not permitted to practice outside of the Army —that is, to engage in private practice?

DR. TIGNOR. They devote their entire time to the Army, just as the officers of the Medical Department do. They are not prohibited from giving relief in case some one is suffering who is on the post. Their time is not taken up entirely with the enlisted personnel or the officers.

Under the present regulations officers' families and all civilian employees at the posts are entitled to receive medical and dental treatment.

MR. McKENZIE. I wanted to know whether you have any other opportunity for receiving remuneration—that is, whether you have an opportunity to make anything other than what you are paid by the Government?

DR. TIGNOR. Yes, sir.

MR. McKENZIE. As to whether your income would be limited to that which you receive from the Government?

DR. TIGNOR. No, sir.

MR. SHALLENBARGER. How many colonels and how many majors would be created by your proposition?

DR. TIGNOR. One colonel, and 25 per cent of the corps to be majors.

MR. SHALLENBERGER. How many majors would that give you?

DR. TIGNOR. Under the present organization, with a strength of 100,000 men, that would give us 25 majors. I do not know what the proposed increase of the Army is.

MR. SHALLENBERGER. How long have these men served?

DR. TIGNOR. A great many of them have served 15 years. The corps was organized on February 2, 1901. A great many men now in the corps have served 15 years, and there are a few men in the service who have served only 5 years.

MR. SHALLENBERGER. Do you think they should be created majors when they have only had that amount of service?

DR. TIGNOR. I think a clause should be added requiring at least 10 years service.

MR. SHALLENBERGER. In the Infantry arm of the service the average service of a major is longer than 10 years, it is not?

DR. TIGNOR. In the Infantry branch the average service is longer than that; but when the men of the Dental Corps

enter the service they enter it with a full knowledge of their profession; they are fully equipped. I believe in the case of the members of the Staff Corps they spend the first few years of their service in learning their profession. Take the other Staff Corps, the great majority of the men in the Medical Corps who are majors have served less than 8 years when they reached the grade of major. In some cases the service is more than 15 years.

The only corps in the service which is limited, in which there is a time limit before a man reaches the grade of major, is in the Corps of Chaplains. A chaplain can not be promoted to be a major until he has had 10 years' service.

MR. SHALLENBERGER. As a matter of fact, there are many second lieutenants who are not promoted from the grade of second lieutenant until they have served longer than some men in your corps who are majors; is that not true?

DR. TIGNOR. No, it is not.

MR. KAHN. According to reports we read at the outbreak of the present European war, there were a great many men rejected in England on account of defective teeth. Do you think that recruiting could be increased in this country if some simple operations on the part of dentists would make men more fit to enter the service?

DR. TIGNOR. I am sure of it. I have served for nearly 10 years at one of the larger recruit depots. I have examined about 10,000 men a year during that time and from my observation there I am very sure that the numbers could be increased.

THE CHAIRMAN. We are very much obliged to you, Doctor.

STATEMENT OF DR. C. B. GIFFORD, OF NORFOLK, VA.

THE CHAIRMAN. Dr. Gifford desires to make a statement to the committee, and we will be glad to hear him now.

DR. GIFFORD. Mr. Chairman, there is very little left for me to say, as Dr. Brown and Dr. Tignor have covered the ground thoroly from my viewpoint.

There is one point I would like to elaborate upon. The Dental Corps as it is organized to-day presents not only a reactionary condition, but is a reflection upon the profession, and that is why the National Dental Association is behind this proposition. That is the fundamental reason.

The conditions in the corps are not inviting, and when a man enters the corps there is no incentive for study; there is no incentive in the way of promotion; and the men, naturally, do not improve their minds.

The result has been that men like Dr. Tignor have been in the corps for 15 years without any opportunity for promotion. Knowing Dr. Tignor as I do, I know that he is one of the few loyal men who have hung on. A lot of men who have been in the corps have become disgusted and discouraged.

THE CHAIRMAN. What you mean to say is that owing to the fact that there is only one grade and the salary is fixed, and when they go into the corps they do not study or keep up with their profession?

DR. GIFFORD. Not that. My point is that there is no incentive for study or for preparation for promotion.

THE CHAIRMAN. That means the same thing, I take it.

DR. GIFFORD. Not exactly. If you are in a position where you are bound to stagnate, conditions become cloudy about you.

THE CHAIRMAN. That is what I say. If they do not study, it does not make any difference?

DR. GIFFORD. I would not put it that way. I would not put it on that basis at all.

THE CHAIRMAN. I mean, they do not lose their rank, they do not lose their pay, and they do not have to stand any more examinations?

DR. GIFFORD. That is true at the present time, but the conditions are not inviting to the members of our profession.

THE CHAIRMAN. That is the point. Because they do not get any increased rank they do not have to study, and they are not as efficient as they ought to be?

DR. GIFFORD. In a sense that may true, but the conditions could be removed by the suggestions which have been put forth.

THE CHAIRMAN. We are very much obliged to you, Doctor.

(Thereupon, at 12.45 o'clock p. m., the committee adjourned to meet to-morrow, Friday, February 4, 1916, at 10 o'clock a. m.)

GENERAL GORGAS' HEARING.

February 20th I received copy of the Congressional Record giving the hearing of General Gorgas before the Senate and House Military Affairs Committees. The provisions relative to the Dental Corps were the same that had been read to our Committee when in Washington in November and it seemed as tho we had not made any headway with this department. In order that the Surgeon General could better understand our position, the following day letter telegram was sent to him:

"February 20, 1916.

Surgeon General William C. Gorgas,

War Department, Washington, D. C.

The National Dental Association of nearly twenty thousand members and an equal number in other Dental Organizations must vigorously oppose the Contract Status and the relative rank for Dental Corps as proposed in your recently published bill. We consider this discrimination as unnecessary and humiliating and must insist that our representatives in Army be accorded dignified recognition and actual rank in keeping with importance of service rendered. We prefer to co-operate with you and will greatly appreciate your support but under herein mentioned conditions we have no choice. Wire, collect, advising if your attitude is misunderstood or any change in situation.

(Signed):

HOMER C. BROWN, Chairman,
Legislative Committee."

Night letter telegrams were also sent to Chairmen Chamberlain and Hay, of the Senate and House Military Affairs Committee:

"National Dental Association must vigorously oppose General Gorgas' plan for Contract status and relative rank for Army Dental Corps. Contract system should be eliminated and actual rank provided as embodied in our hearing before your committee. If consistent, will greatly appreciate a wire, collect, regarding our prospects."

Herewith incorporate General Gorgas' reply:

"Dr. Homer C. Brown, Chairman,
Legislative Committee, National Dental Association,
Columbus, Ohio.

My desire is to increase the efficiency of the Dental Corps and provide for a proper flow of promotion. The question of the titles given to the various grades is, I believe, a matter of secondary importance. There is no objection upon my part to the same provision regarding rank as is now authorized for the Medical Corps.

(Signed): GORGAS."

Excerpt of Hearing of General Gorgas, Surgeon General of the Army Before Senate Military Committee.

SENATOR THOMAS. General, I have received a number of letters, and I have no doubt that the other members of the committee have also, from certain dental organizations in the country urging the organization of a dental corps along the lines of the Medical Corps, and largely for the same reasons. I would like to get your view of that subject before you leave us.

GEN. GORGAS. I think it is a very good and desirable thing. Such a scheme has been adopted in most of the European armies. We have at present a very good Dental Corps, partly commissioned in the rank of first lieutenant and partly civilian. **The tentative draft of bill which I have had made provides for some increases of rank up to major, which I think is adequate, and should be satisfactory to the dental associations.** I understand that the dentists are asking for a colonel as an assistant to the Surgeon General in his office. I see no necessity for this.

THE CHAIRMAN. We have given them an opportunity to be heard.

SENATOR CATRON. They have not been heard yet, have they?

THE CHAIRMAN. No. They are to be here Wednesday morning. They will have a representative here.

Nov. 6th. 1915.

Hon. W. H. Osborne, Commissioner of Internal Revenue, Washington, D. C.

Sir:—

Members of Legislative Committee of the National Dental Association called at your office Thursday and conferred with representatives of your Department, regarding the application of the Harrison Narcotic Law to dentists.

The first interpretation and instructions were to the effect that dentists, when personally administering or applying these drugs, were exempt from keeping a complete and detailed record. Later, a definition of "personal attendance," and a subsequent ruling, completely changed the situation, but to me this definition would not seem to be in keeping with the letter or the spirit of this Section.

The services rendered by the dentist call for the use of such drugs as are enumerated in this law and our profession should be and is willing, I am quite sure, to co-operate with your Department in any reasonable way, especially so when such regulations have for their purpose the bettering of the conditions of our citizenship. However, in doing this, no undue or unnecessary hardships should be imposed by requiring such full record details, since it will be generally admitted by all who are in any way familiar with the procedure that it is next to impossible to keep a record that is in any sense accurate or satisfactory to either the dentist or representatives of your Department.

Some relief had been provided for those administering minute quantities of stock solutions of such drugs, but such solutions deteriorate with age and thus present a distinct disadvantage.

We fully recognize the impossibility of passing any legislation, such as this, without the necessity of corrective amendments, but in this case it would seem that a more liberal interpretation of "personal attendance" will eliminate the objectionable feature so far as the dental profession is concerned.

An early reply will be appreciated and, as explained to your representatives, we will probably publish this in the Journal of our Association, especially if your communication gives us any relief.

Respectfully,

HOMER C. BROWN, Chairman,
Legislative Committee, N. D. A.

Treasury Department, Washington,
November 12, 1915.

Homer C. Brown, Chairman,
Legislative Committee, N. D. A.,
Columbus, Ohio.

Sir: Referring to your letter of November 6th, relative to the application of the Harrison Narcotic Law to Dentists in the matter of keeping records, you are advised that the paragraph in Treasury Decision No. 2172, headed "drugs dispensed, record of," relates particularly to physicians and dentists who are engaged in a special practice necessitating the use of minute quantities of narcotic drugs.

In this ruling, the words "a physician or dentist who administers minute quantities of drugs coming within the scope of this law in his office may keep a record of the date when a stock solution is made and the date when such stock solution is exhausted without keeping a record of the name and address of each patient to whom such drugs are administered," **may be extended to any preparation, whether liquid or solid, where the quantities used are so small that to estimate their weight would be practically impossible.**

In the case of stock solutions, the date when such solution is prepared and the date when destroyed or exhausted should be noted. When solid preparations are purchased, the date when the container is opened and the date when its contents are exhausted, should be noted. Were the words "personal attendance" given the meaning as indicated in your letter, dentists would not have to keep any record whatever, and it is obviously not the purpose of Congress to exempt those persons from keeping such record as will enable the Government to keep a check on the disposition made of narcotic drugs.

Respectfully,
G. E. FLETCHER,
Acting Commissioner.

EXCERPT FROM ARMY AND NAVY REGISTER* FEB. 6, 1916.

Dr. Homer C. Brown, of Columbus, Ohio, chairman of the Legislative Committee of the National Dental Association, quoted from the reports in the Army and Navy Register of Gen. Gorgas' testimony regarding the progress in dental observation as a contribution to the availability of men for military duty and emphasized the extension of dentistry as a means of protecting men in arms. He urged provision for a dental reserve corps, similar to the medical reserve corps, to replace the acting dental surgeons, except that these reservists shall be obligated to serve when called upon for active duty; that there be created a dental corps composed of first lieutenants who have served two years in the reserves, captains who shall be promoted from first lieutenants after seven years' total dental service, majors equal to 25 per cent, of the corps promoted by seniority from the captains, one colonel who shall be chief of corps and who will have a tour of duty for four years to be appointed by the President, the strength of corps personnel to be, as now, one to 1,000 of men.

It was recommended that service as acting dental surgeon and so on be computed as military service. Dr. Brown made a straight-forward appeal for a dental corps on the new basis.

Dr. Brown said: "With an increased dental corps, and in the interest of efficiency and economy, there is every reason for having a representative of the corps, with rank of colonel, stationed in the surgeon general's office to co-operate with him in the administrative affairs of the dental corps. The right to command by virtue of a commissioned corps, with actual rank, cannot conflict with any other department, as this right can

*The Army and Navy Journal published a more extended report, but the lack of space forbids its publication.

be limited by Congress to the dental corps and their enlisted assistants."

He was followed by Dr. E. P. Tignor, a first lieutenant in the dental corps, who stated that the first year's cost of the proposed increase would be between $18,000 and $20,000 and afterward $2,000 or $3,000 a year. The idea of a definite percentage of majors was to insure a reasonable degree of promotion. Dr. Brown brought out the fact that much of value was being done in Europe by the dental surgeons in preventive work to the manifest advantage of the fighting personnel.

Mr. Shallenberger was curious about the length of time necessary to become a major as compared with line officers, and was informed that most staff officers served less than eight years before reaching a majority.

Dr. C. B. Gifford, of Norfolk, described the disadvantage of a one-grade corps in discouraging study and offering no incentive to enter the corps.

RESOLUTIONS ADOPTED BY COLUMBUS ACADEMY OF MEDICINE, COLUMBUS, OHIO, FEB. 28, 1916.

"Whereas, The detrimental influence of pathological conditions upon the entire system is becoming quite generally recognized, and,

Whereas, The greatest progress in preventative medicine can be promoted, and the best interests of humanity served, thru a harmonious co-operation of physicians and dentists. This being especially true of service in the United States Army and Navy. Therefore, be it

Resolved, That the Columbus (Ohio) Academy of Medicine recognizes this close relation, as well as the importance of such co-operation, and heartily endorses the efforts of the Legislative Committee of the National Dental Association to increase the efficiency and raise the status of their representatives in the Army and Navy services, as follows:

(1) By eliminating the contract status and providing in its stead a Dental Reserve Corps.

(2) By providing actual rank and a proper flow of promotion, to and including one Colonel, as head of the Corps. Be it further

Resolved, That the Secretary is hereby authorized to forward copies of these resolutions to Brig. Gen. Wm. C. Gorgas, Senators George E. Chamberlain, Atlee Pomerene, Warren G. Harding, Congressman James Hay and Clement Brumbaugh."

ST. LOUIS MEDICAL SOCIETY ENDORSES PROPOSED LEGISLATION.

The following resolution was unanimously adopted at the last meeting of the St. Louis Medical Society:

Whereas, Modern dentistry is an aid in the prevention and cure of many grave constitutional diseases as well as in the maintenance of general health, and

Whereas, The character of wounds about the head and face inflicted by modern implements of war makes the services of competent dentists an indispensable aid to the Army Surgeon in time of service, and

Whereas, The efficiency of the Army both in times of peace and war depends primarily upon the physical fitness of its members,

Therefore, Be it Resolved, That the St. Louis Medical Society heartily endorses the action of the National Dental Association in seeking such legislative enactments as will offer inducements to the better class of dentists to enter the Federal Service, and

Be It Further Resolved, **That it petitions Missouri representatives in both branches of our National Assembly to support the efforts of the National Dental Association to secure three additional grades in the Dental Corps of the United States Army.**

Passed by St. Louis Medical Society February 26, 1916.

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OTTO U. KING, D. D. S.,
Huntington, Indiana.

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VOL. 3 MARCH, 1916 No. 1

EDITORIAL DEPARTMENT.

OPENING OF THE RESEARCH INSTITUTE OF THE NATIONAL DENTAL ASSOCIATION.

One of the greatest steps forward in dental advancement was made on February 7, 1916, when the Research Institute of the National Dental Association was formally opened in Cleveland, Ohio.

Your President was there and had the pleasure of being one of the speakers on this auspicious occasion. For the information of the members of the National Dental Association, I have thought it wise at this time to give a short outline of the policies of the Research Institute, as well as the reasons for its location in Cleveland and the purchase of the building.

Acting under the authority vested in them at Kansas City, the Trustees of the Foundation and Research Commission of the National Dental Association proceeded to incorporate under the laws of some

state that was most favorable to institutions of its kind. At the Rochester meeting of the National Dental Association, it was thought best to look over the charter laws of New York State. After securing legal advice and expending a great deal of time trying to get a satisfactory charter under the laws of New York, it was found that it would be impossible to use a charter obtained in New York for our institution, therefore, the trustees had to look elsewhere. The laws of every state were completely canvassed, and, after expert legal advice was obtained, it was found that the laws of the state of Ohio were most favorable for our institution. Therefore, the Board of Trustees of the Foundation and Research Commission of the National Dental Association secured its charter in Ohio.

Acting under the instructions of the Foundation and Research Commission of the N. D. A., the trustees named the institute "The Research Institute of the National Dental Association," and a formal transfer of the properties, etc., was made to the newly chartered institution at a meeting of the Trustees of the Foundation and Research Commission at Cleveland, Ohio, September 25, 1915.

Under our charter, the members of the Foundation and Research Commission become Commission members of the Institute, and other men are added to the Institute members who are known as "permanent members". These permanent members are men of distinction in the United States and are not dentists. These two classes of members constitute the body of the Research Institute and they elect the Trustees who control the business affairs of the institution. However, the Constitution of the Research Institute provides that of the Board of Trustees, five shall be elected from the Research Commission of the N. D. A., thus giving dental members a majority on the Board. Under our charter, it will be impossible ever to take the control of the Institute out of the hands of the National Dental Association. The laws of Ohio provide that a majority of the members of the Board of Trustees be residents of the state, and further provide that each member of this board shall be individually responsible for the debts of the institution.

Thus far, we have only outlined the formation of the Institute. Now, as to its present policies. There never has been any effort to centralize the work of the Institute, and the grants that have been made to the various research workers in different sections of the country not only have been continued by the Board of Trustees but have been amplified by two additional grants this year, namely, Dr. Percy Howe, of Boston, and Dr. John Callahan, of Cincinnati, and it is the intention of the trustees to continue this policy whenever funds are available.

Now, as to the use of the funds that have been subscribed for research work; these have been carefully and judiciously administered. Not one cent of this money has been used in the purchase of the

Institute building or its furnishing. The bulk of the money that so far has been paid on the building has come from the trustees of the Institute and the dental profession of Ohio. The Ohio State Dental Society gave $4000.00 from its funds to be applied on the purchase of the building. The Cleveland dentists have given $5000.00 and the citizens of Cleveland have subscribed quite liberally to its purchase. Also, dentists from all over the United States have sent in funds to be applied on the purchase of the building.

As to the building itself,—it has three stories and a cement floored basement and has been found to require practically no alterations. This handsome building cost originally $75,000.00 and the ground is valued at $45,000.00. The whole property was purchased for $50,000.00, and the owner, who is intensely interested in our work, has donated $2,000.00 on the purchase price, leaving the net cost to the Institute $48,000.00, or $3,000 above the value of the ground.

Several philanthropists in Cleveland are very much interested in our work and have indicated that, at the proper time, they will give us substantial aid.

The reason that I, as President of the National Dental Association, have deemed it wise to write this editorial is because I believe the members of the National Dental Association should understand fully just what the Research Commission has done. No one can realize the great personal sacrifice that has been made by the President of the Research Institute in getting the Research propaganda before the profession, and how much actual money he has spent from his own funds to advance the research work. In the last three years, to my personal knowledge, he has given nearly $2,000.00 in money to pay the expenses of the research workers, and in addition to that, has given time that actually cost him $5000.00 per year. I doubt if there are many men in our profession, or any other, that would give as freely of themselves and their substance as Weston A. Price has done for our research work.

Dr. Weston A. Price is only acting managing director, elected over his protest, the regular managing director will be elected as soon as an available man can be found. Dr. Price receives no pay or emolument for the service he is rendering.

In the opening exercises, we had the honor of having two of the greatest surgeons in the United States, or the world, to give us addresses. Dr. Charles Mayo came all the way from Rochester, Minnesota, to give us a forty minute talk and his presence was an inspiration to us all. He is vitally interested in our research work and is doing all he can to help us. Dr. George Crile was there too. He is on our Board of Trustees and is so much interested in our work that he is willing to give of his valuable time and money to help and encourage us.

We have one of the greatest institutions in the world, started by dentists for the advancement of their profession and the uplift of humanity, and now is the time for

us all to bid it God speed, and help with our means in proportion to what God has blessed us with. Have you done your part?

THOMAS P. HINMAN.

PREPAREDNESS — HOW DOES IT AFFECT YOU?

At this time when preparedness is engrossing the attention of the whole country, the question can well be asked, "How does it affect me personally?" If Congress adopts the Federalized Militia, or any kind of reserve force of 500,000 men, it will be necessary for a large number of dentists to join the reserve force. Federal laws apply to any militia or reserve force, and under them, one dental surgeon is appointed for every thousand enlisted men. Five hundred civil dentists will be our professional quota to preparedness. Do you realize that provided a sufficient number of dentists do not voluntarily offer their services, that there will undoubtedly be some provision for compulsory service? Furthermore, do you realize that if you should join the United States service, voluntarily or otherwise, as a dental surgeon, you would not be an officer? Such is a fact. Under the present Federal law, you would sign a contract for three years service and during that period you would be neither an officer nor an enlisted man, and therefore would not be entitled to a pension or retirement due to disability from disease or injury acquired in line of duty. Your family would not be entitled to a pension in case of death. You would not wear the uniform of an officer, but the distinctive uniform of a contract man (and the Dental Corps are the only Corps in the whole United States Army wearing such) which emblazons the fact that you have contracted to furnish your professional services, same as other Army contractors furnish food, ammunition, horses, etc. Your standing in the community may be of the highest, but after joining the colors it is judged by the commission you hold. Rank is everything in the Army and without it, you are a nonentity. After three years service, you would be entitled to a commission as a First Lieutenant, provided you passed the examination. Further than this, there is **no** promotion. A dental surgeon ranks below every other first lieutenant of the Army of whatever branch, and any officer receiving his promotion to a first lieutenancy automatically jumps all dental surgeon first lieutenants irrespective of length of service of whatever branch and can rank the dental surgeon out of quarters. Ministers enter the Army as First Lieutenants with promotion to Majors, inclusive; Engineers enter as Second Lieutenants with promotion to General, inclusive; Lawyers enter as Majors, with promotion to General, inclusive; Physicians enter as First Lieutenants with promotion to General, inclusive; and Veterinarians have a bill in both branches of Congress to enter as Second Lieutenants with promotion to Majors, inclusive. **Why this discrimination against the dental profession?**

Such is not the case in the armies of other great powers. The European and Canadian Armies have commissioned dental corps with grades as high as Colonels. These men have rendered such invaluable service to the soldiers wounded in this great war, that the world has been made to realize that the dental surgeon is an indispensable member of all military organizations.

Now, Brother Dentist, we know you would rather serve your country as an officer; in a capacity befitting yourself respect and profession, therefore we request your aid in securing, during this present session of Congress, an enactment of laws to remedy the deplorable condition existing relative to the dental profession in the United States Military Service.

Our Association, thru its Legislative Committee, is attempting to have certain measures inserted in the Defense Bills which the Senate and House Military Affairs Committees will present to Congress. Whether our measure is regularly incorporated into the Defense Bills, or whether we are compelled to have it introduced separately, we expect each and every one of the 20,000 members of this Association to help in this campaign. The present time is our opportunity. We want every individual member to get in touch with men who are close to the Chairmen of the State and local political organizations to which your Senators and Representatives belong, and have these Chairmen write or send night telegrams to each Senator and Congressmen and request that **they support on the floor of Congress, the recommendations of the Legislative Committee of the National Dental Association as submitted to the Senate Military Committee, Feb. 2nd, and to the House Military Committee, February 3rd.**

Your General Secretary will keep the Secretaries of each state society informed as to what is being done in Congress; the progress made and the plans of the legislative committee. In this campaign for a more efficient Army Corps and the raising of the standard of our profession, we will need not only all our forty-two centimeter guns, as represented by our great and smaller component societies, but in this battle for justice, we must depend on the **individual dentist.**

WHY THE DENTAL PROFESSION IS ENTITLED TO RANK.

How can any unbiased person object to giving rank to the officers of the Dental Corps in view of the statement of the Judge Advocate General of the Army, to the effect that **"all commissioned officers of the Army are assigned military rank** by express operation law, they are not all equally eligible to exercise military command"? The granting of rank to any officer can only mean that that officer shall have the same official standing and the same consideration as other officers. The dental surgeon is required to sit on court-martials, on boards of inquiry, in fact is eligible to every

duty to which other officers in general are eligible. Is it because the dental surgeon's province is to **keep** the men available for service, and the line officer's province is to show these men how to serve, that the former should not receive equal consideration in his grade with the latter? There is no desire on the part of members of the Dental Corps for military title or command. There is nothing but the desire for a dignified, equitable and definite status.

Not considering the officers of the line detailed therein, the officers of the Adjutant General's Department, the Inspector General's Department, the Judge Advocate General's department (certainly this department will never be called upon to command troops), the Ordinance Department, the Quartermaster Corps, the Corps of Engineers, the Signal Corps, and the Medical Corps, all "staff officers," have rank the same as all other officers and have had rank for many years, and surely no one has ever contended that either their efficiency or the efficiency of the line of the Army has suffered thereby.

It is fair to assume that these officers do not desire rank for purposes of command. Why, then, do they desire it? Merely that they may have a definite and clear military status, so that they may be on an equality with those with whom they are associated, not as a matter of sufferance, a most humiliating status, but as a matter of right, and this is the reason, and the sole reason, why rank is desired for the officers of the Dental Corps. The Executive retains at all times the right to promulgate such special regulations concerning these officers as special conditions may seem to make necessary, as he does in respect to all other branches of the service.

If the members of the Dental Corps are given a status the same as that of other officers, the personnel will be a contented one, the class of men seeking entrance to the Dental Corps a desirable one, and there will be the consequent increased efficiency incident to a contented frame of mind and a better class of men in the service, and this without one dollar of increased expense to the Government. If rank (not title or right to command) is withheld and these officers are thrown upon the charity of other officers for their official and social status, there must be a discontented personnel which must necessarily interfere with the efficiency of the service rendered.

The dental profession asks no special favors in this matter; all it asks and desires is legislation that will be fair and equitable, and that will grant to the members of the dental profession equality in their grades with that of other officers in like grades.

*ANNOUNCEMENTS.

NATIONAL SOCIETIES.

American Society of Orthodontists, Pittsburgh, Pa., July 20-22.

National Dental Association, Louisville, Kentucky, July 25-28.

National Association of Dental Examiners, July 24.

National Association of Dental Faculties, July 22-24.

Educational Council of America, July 24.

STATE SOCIETIES.

April.

Alabama—Mobile, April 11.

Michigan—Detroit, April 13-14-15.

West Virginia—Charleston, April 12-13-14.

May.

Illinois, Springfield, May 9-10-11-12.

Indiana—Indianapolis, May 16-17-18.

Iowa—Des Moines, May 2-3-4.

Massachusetts—Boston, May 3-4-5.

Mississippi—Jackson, May 2-3-4.

Nebraska—Lincoln, May 15-16-17-18.

New York—Albany, May 11-12-13.

North Dakota—Grand Forks, May 9-10.

South Dakota—Sioux Falls, May 12-13.

Texas—Dallas, May 9-10-11-12.

Vermont—Burlington, May 17-18.

June.

Colorado—Manitou, June 22-23-24.

Connecticut—New London, June 13-14-15.

Florida—Orlando, June 21-22-23.

Georgia—Macon, June 8-9-10.

New Hampshire—Lake Sunapee, June 20-21-22.

North Carolina—Asheville, June 21-22-23.

Pennsylvania—Pittsburgh, June 27-28-29.

Southern California — Los Angeles, June.

Utah—Salt Lake City, June.

Wyoming—Casper. June.

July.

Kentucky—Louisville, July 24.

New Jersey—Asbury Park, July 12-13-14-15.

Porto Rico—San Juan, July.

South Carolina—Chick's Springs, July 11-12-13.

Wisconsin—Wausau, July 11-12-13.

October.

District of Columbia—Washington, October 19 and monthly.

Virginia—Richmond, October 18-19-20.

November.

Arizona—Phoenix, November.

December.

National Capital—Washington, December 5 and monthly.

Ohio—Dayton, December 5-6-7.

*The Legislative Department reports were so voluminous that three pages of announcements were omitted, owing to lack of space.—Editor.

"WOULD ELEVATE DENTAL CORPS.

Senator Pomerene proposed today an amendment* to elevate the standing and dignity of the dental corps of the army. The experience of the war in Europe demonstrated that the dental surgeon plan is a very important part in the maintenance of the highest military efficiency.

The army bill in its present form before the senate provides that dental surgeons during the first 10 years of their service shall have the pay and allowances of a first lieutenant; between 10 and 25 years of service, the pay and allowances of captain, and after 25 years they shall have the pay and allowances of a major.

Senator Pomerene today introduced an amendment which gives to an army dental surgeon during the first five years of his service the pay, allowances and rank of first lieutenant; between five and 15 years of service, the pay, allowances and rank of captain and after 15 years the pay, allowances and rank of major. The Pomerene amendment will be offered by its author from the floor of the senate when the army bill reaches the amendment stage."

*This amendment has the approval of the Legislative Committee, Army Dental Corps, and officers of N. D. A.

KOLYNOS

The theory that Pyorrhea is caused by Amebae may or may not come to be generally accepted. One fact is, however, plainly established.

KOLYNOS DENTAL CREAM is a Powerful Amebicide.

We quote below from a report upon "An Investigation into the Amebicidal Properties of Kolynos Cream and Kolynos Liquid," by Dr. Leo F. Rettger, Assistant Professor of Bacteriology and Hygiene, Sheffield Scientific School, Yale University.

"1. Kolynos Dental Cream has a decidedly destructive action on amebae and must therefore be regarded as a strong amebicide. Even in as high a dilution as 1 part of the cream to 300 parts of water, the disinfectant action is complete within 15 minutes, provided encysted forms of the amebae are absent. In dilution of 1 to 400, the action was complete in 30 to 60 minutes. In 1 to 200 solutions very few amebae remained alive after an exposure of 5 minutes.

"2. Liquid Kolynos has practically the same amebicidal action as the dental cream, being a trifle stronger than the cream."

These facts, whether the Amebic Theory be confirmed or rejected, must still have a great interest to all dentists who are familiar with the great efficiency of Kolynos.

SAMPLES MAILED UPON REQUEST.

THE KOLYNOS COMPANY

NEW HAVEN, CONNECTICUT